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TABLE OF CONTENTS.

LEADING ARTICLES:	Page.
Foundations of the Municipal Building, New York City (illustrated)	523
The Barren Jack Masonry Dam in New South Wales	529
The Siphon Lock on the New York State Barge Canal at Oswego, N. Y. (illustrated); D. A. Watt, M. Am. Soc. C. E.	530
Gravity Freight Classification Yard for the Pennsylvania R. R. at Northumberland, Pa. (illustrated); W. A. MacCart	534
Octave Chanute	536
Land Drainage in Illinois	537
An English Gasoline Rock Drill (illustrated)	538
Notes on Construction Methods Used on the Lansing & Northeastern Ry.; Michigan	538
The First Garbage Reduction Works Built by an American City—Columbus, Ohio (illustrated); I. S. Osborn	542
The Decision in the Long-Delayed Peoria Electrolysis Suit	546
First Annual Meeting of the American Association for Study and Prevention of Infant Mortality; C.-E. A. Winslow	547
The Life of an Automatic Sprinkler; C. R. Alling	548
Steel Cars for the Chicago Freight Tunnels (illustrated)	548
EDITORIAL	539
The Responsibility of Electric Railway Companies for Electrolysis of Pipe Lines—A Sound Argument for an Increase in Railway Rates.	
A New Proposal to Secure Power on a Large Scale from Intermittent Natural Sources	539
LETTERS TO THE EDITOR	540
Economic Comparison of Railway Tie Material; E. A. Sterling—Method of Measuring Concrete Work; Leslie H. Allen—Lengths and Deflection Angles of Transition Curves; Robert S. Beard; Wm. G. Raymond—Flies and the Disposal of Garbage and Refuse; Louis I. Tribus—Notes and Queries.	
ENGINEERING NEWS OF THE WEEK	549
PERSONALS	550
ENGINEERING SOCIETIES	550
ENGINEERING LITERATURE SUPPLEMENT	37

Foundations of the Municipal Building, New York City.

The city of New York is building a 25-story-and-tower steel frame office building to house its central department offices. The structure, called the Municipal Building, will occupy an irregular plot of ground opposite the Manhattan entrance to the Brooklyn Bridge. The plans, which were the product of a limited competition among architects in which the firm of McKim, Mead & White was victorious, represent a combination of good external appearance with satisfactory utilization of floor space. An architect's perspective is reproduced in the adjoining cut, and a floor-plan is shown in Fig. 2.

As a whole the building is remarkable, in purpose, in design and in dimensions. Not least of its notable features is the fact that it crosses a main street, passing the street through a wide arcade directly under the tower.

DEEP PNEUMATIC WORK.—More remarkable than the external features, however, are the foundations on which the building will be carried. These have been in course of construction since the summer of 1909, and were completed in September, 1910. They are pneumatic caisson piers, sunk through fine waterbearing sand. Most of them go to rock, and as rock lies very deep the caisson work had to be conducted practically at the maximum depths to which this class of work is possible. A New York State law of 1909, regulating compressed-air labor, under which 50 lbs. is the maximum permissible pressure, set a limit which was almost exactly reached in this undertaking.

FOUNDATION PARTLY ON SAND.—Over part of the site the rock dipped so low that it was impossible to sink piers down to it by the pneumatic process. The fact was discovered only after the foundation contract was signed and work started. Very serious discussion arose as to the proper procedure for securing a satisfactory foundation on this part of the site. The result, as reported in some detail in our issue of Jan. 6, 1910, p. 24, was the decision to carry

THE NEW MUNICIPAL BUILDING, NEW YORK, FROM THE WEST.
(From an Architect's Perspective.)

these caissons down for only part of the depth to rock, founding them on a stratum of good, coarse sand at suitably reduced loading. The building therefore will be carried partly on bed rock and partly on sand. So far as we are aware, no building of such weight and size has ever been supported in this way.

CONCRETE CAISSONS.—In the details of the foundation work, the use of caissons made of reinforced concrete is notable, being a new departure in pneumatic work for foundations of buildings. The smaller caissons were made of wood or of steel, as hitherto customary, but those large enough to permit of using concrete without reducing the clear width of the working chamber too much were built of this material.

It is also worth note that the foundation area is unusually large, the building having a large ground area. This fact facilitated the complicated work, but it made the foundation construction cover an unusually long period of time. The influence of both size and depth is revealed in the price paid for the caisson foundations: the sum of $1,443,147 according to the original contract, or $33.80 per square foot of ground area covered by the building.*

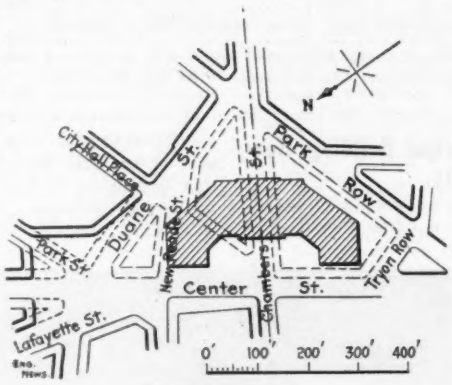
deposit directly on the rock. Occasional boulders lay in the sand, as developed later, and one of these was responsible for an 84-ft. error of depth in one of the preliminary wash borings, preventing the timely discovery of the downward dip of the rock surface over the northerly part of the site.

ADJACENT STRUCTURES.—While the site is bounded on all sides by streets, so that there was no trouble about adjacent buildings, this favorable feature was counterbalanced by the presence of the Third Avenue Elevated Railway structure along Park Row, bounding the site on the east, and the four-track Interborough rapid-transit subway in Center St., on the west. The foundations of the elevated-railway columns were pyramidal brick piers, with bases 8 to 12 ft. below street level. These required to be carried down much deeper before the building excavation could be completed, as the lowest level of the latter (El. — 5.8 ft.) was to be about 38 ft. below curb (see Fig. 6). The Center St. Subway floor was about 12 ft. above the bottom of the building excavation. However, a bench of earth about 20 ft. wide was left alongside the subway, with top at its floor level, retained by a concrete wall on the inner face. Steel sheet piling was also driven along the subway wall.

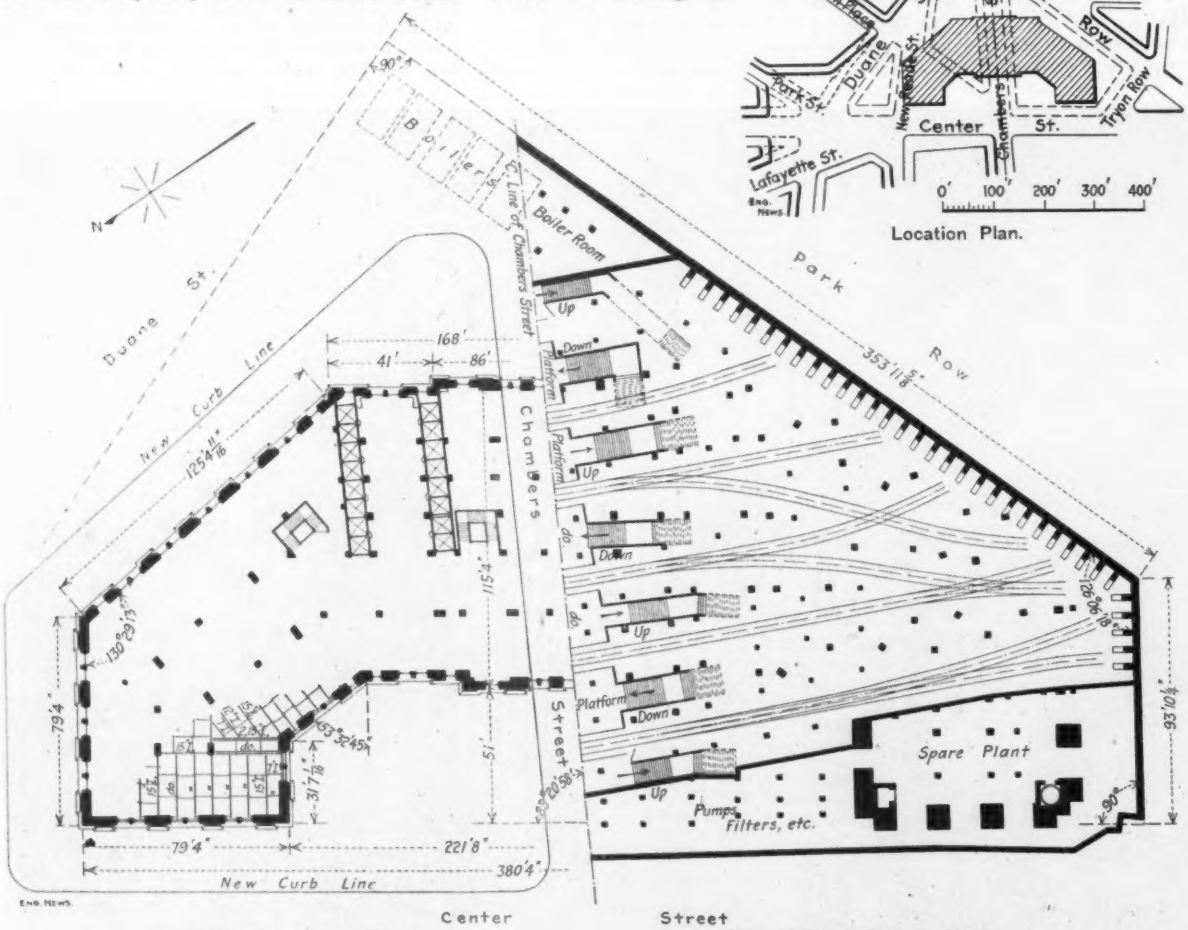
Both these structures were matters of anxiety throughout the foundation work, since any displacement causing a flow of sand from under them was liable to create dangerous conditions. Settlements up to 6 ins. appeared in the elevated-railway columns. The settlement of the subway was practically zero, probably because of the steel sheeting, which was driven to a level about 9 ft. below the floor of the building excavation.

A bank of electric-cable ducts crossed the site near its northerly end, carrying feeder cables of the Interborough subway. Interruption of the power supply through these ducts would have been extremely serious, and it was necessary therefore to support and protect the ducts most carefully throughout the work. Being about 30 ft. above the floor of the excavation, they had to be cradled and supported by shores. They were not damaged at any time during the foundation work.

A further complication lay in the fact that the site is crossed at midlength by Chambers St., which will pass through the completed building as an arcade. This is an important traffic street, and could not be closed at any stage. It carried several important water mains. Consequently a timber trestle had to be built under it when the site was excavated. The derrick travelers and other plant were thus prevented from moving freely from the south to the north half of the excavation, and the possibilities of arrangement of the work were thereby limited.



Location Plan.



Plan of Upper Floors. Plan of Track Floor in Basement.

FIG. 2. GROUND PLAN, MUNICIPAL BUILDING, CITY OF NEW YORK.

*Counting here only the cross-sectional area of the main shaft of the structure, 42,686 sq. ft., or practically one acre. The portion below ground has an area over twice as great, namely, 92,676 sq. ft., of which 69,314 sq. ft. is the area of the track floor of the Loop Subway terminal station and the remainder is boiler and pump room, etc. However, the price stated above does not include the cost of minor column footings, of which there is a large number.

General Conditions.

SOIL.—The subsoil of lower New York is sand overlying the schistose bed rock, which latter is found at the depths generally 25 to 80 ft. below tide level. At the location of the municipal building, as preliminary wash borings showed, the rock surface is about 130 ft. below street level, or about 96 to 100 ft. below groundwater level. Groundwater is about 7 ft. below mean tide level.

The soil overlying the rock was sand, of varying grades from coarse as fine gravel to running sand. Clay, where found at all, was in a thin

Unlike most tall buildings, which (being on small plots and with no free ground adjoining) offer to the builder exceedingly cramped accommodations, the Municipal Building is large enough to give the builder some elbow-room. (See the views of work in progress, Figs. 4, 9, 10 and 11.) Further room was afforded by a triangle of unoccupied space at the north end of the site, excavated to cellar level in connection with the Center St. Loop Subway level.

A SUBWAY TERMINAL IN BASEMENT.—An interesting feature of the Municipal Building is that its basement story is to serve as part of the Chambers street station of the four-track Center St. Loop Subway, which is to connect the Williamsburg, Manhattan and Brooklyn bridges. The Subway is completed (except for Section 9-0-1 under and near the building) but is not yet in use. It was projected originally as an actual connection of the rapid-transit tracks of the three bridges, so that, by means of a similar connection line on the Brooklyn side, a continuous traffic loop would be formed. At present, however, the plan is to construct the station, under and adjacent to the Municipal Building, to a connection with the completed subway structure, and not continue the tracks up to join the Brooklyn Bridge tracks, though provision for making such connection in future is included in the design of the building. The station, as planned, has six tracks, which are assumed to give sufficient capacity to develop the full possibilities of the four-track line. An approximate idea of the arrangement of the trackage may be obtained from the part plan in Fig. 2. But four tracks of the station will be constructed now; the construction of the two easterly tracks is postponed to some future time by the Public Service Commission, under whose jurisdiction the subway was built.

This station determined in large part the column spacing as also the footing level for the building. The caisson piers had to be constructed so as to terminate below the track level. The tracks and the station platforms rest in general on the ground between the caissons, so as to

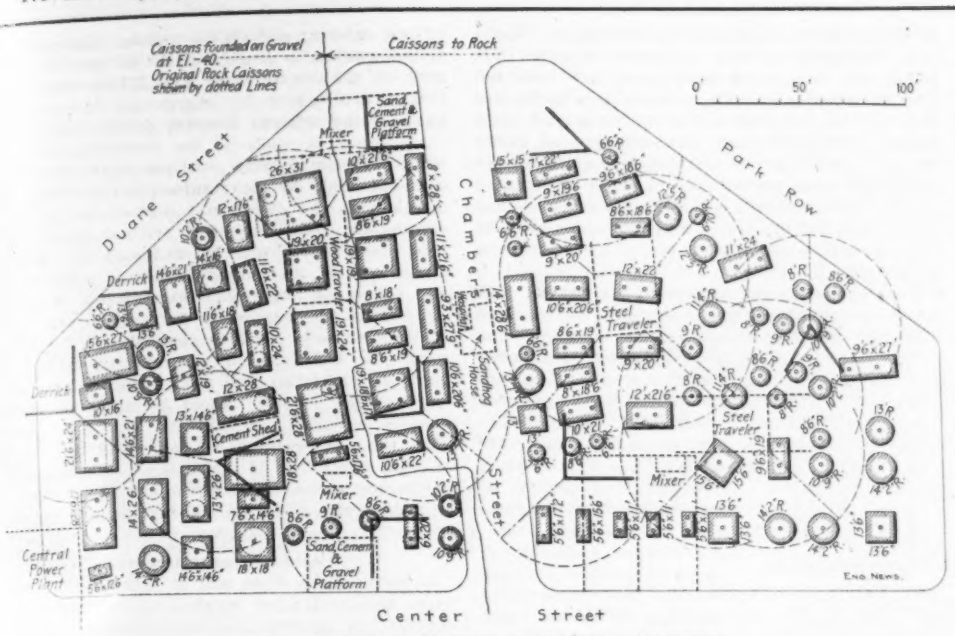


FIG. 3. CAISSON PLAN FOR MUNICIPAL BUILDING.

(Original layout of caissons for rock foundation in north portion shown by dotted lines. The layout of the working plant is shown as it existed when approximately half the foundation work was completed.)

make the building structure independent of the railway, so far as possible. The columns, of course, had to be placed where the track location dictated, and as this did not suit the floor utilization of the building it was necessary to shift the columns at the first-floor level, using heavy plate-girders.

A similar structural complication was introduced by the Chambers St. arcade, which, having no columns on a width of 40 ft. clear, required an enormously heavy girder system at the third-floor level to carry the columns above the arcade and transfer the loads to caissons bordering the arcade on the north and south. These caissons are as a whole the heaviest-loaded group in the entire foundation, and are the largest in area. As will be seen from the plan Fig. 3, these caissons are of such size as to leave almost minimum sinking clearance between them. All caissons of the tower and south wing were proportioned for a load of 15 tons per sq. ft. under the grillage. Those under the north wing carry 6 tons per sq. ft. on sand.

Type of Foundation.

The subway station occupying the whole ground area of the building practically fixed the depth of the building under ground, since any room under the station floor would be useless to the building itself. As the level of the subway track floor is practically coincident with groundwater level, it follows that the entire building and cellar excavation were above water. This made it unnecessary to consider whether or not to adopt a boundary retaining wall of caissons, such as constructed for a number of other tall buildings in New York City. Instead of such a caisson wall a simple retaining wall of steel beams and vertical arches or a buttressed brick wall could be used. The foundation itself was therefore simplified to a series of isolated caissons carrying vertical load only, and the retaining-wall construction became an independent operation.

The difference between the two forms of construction will be more apparent on referring to Fig. 7, a sketch of a foundation built on the caisson-cofferdam method. The foundations of the United States Express Building, corner Church and Rector Sts., New York City, built four years ago, are of this type, and a view in the cellar excavation of that structure, Fig. 8, shows the wall of caissons and its temporary strutting.

The method is adopted when the cellar excavation, in sand, extends well below groundwater. The site is surrounded by a belt of rectangular concrete piers, sunk by the pneumatic caisson process, which are set closely together end to end, about 18 ins. apart, with registering channel recesses in the ends of the caissons. In the key space between these facing recesses, an air-locked shaft is sunk to rock and filled with concrete, thus sealing the cofferdam wall completely. The wall or belt of caissons requires to be braced against the pressure of earth and water before the cellar excavation can be carried down much below groundwater level. When the interior caissons have been sunk and the steel framing of the building is being erected, the timber bracing is gradually replaced by the permanent steel floor-framing, which carries the thrust of the earth across from one wall to the opposite.

In the case of the Municipal Building it was not necessary to resort to this method. Prior to caisson work the excavation had been carried down approximately to the final level, El. 5 ft. 8 ins., with the side banks rising on a natural slope to the street level. There being no buildings adjoining, and groundwater lying below the floor level, it was possible to hold the banks by sheet-piling and build retaining-walls without recourse to caisson methods. The pier caissons in general lie inside the toe of the banks, and could be constructed even before the side sheeting was undertaken. The few caissons nearer the outside of the lot were sunk after sheet-piling had been partly driven to hold the banks, and the earth in front excavated. The underpinning of the elevated-railway columns, however, had to be completed before these caissons could safely be started.

The work, therefore, consisted in the main of the straightforward operations of sinking the interior caissons in such order as was most convenient to the arrangement of the handling plant.

Foundation Contract; Revision of Contract.

SAND FOUNDATIONS.—The specifications for the foundation work fixed the pneumatic method.

Four wash borings had been made, which

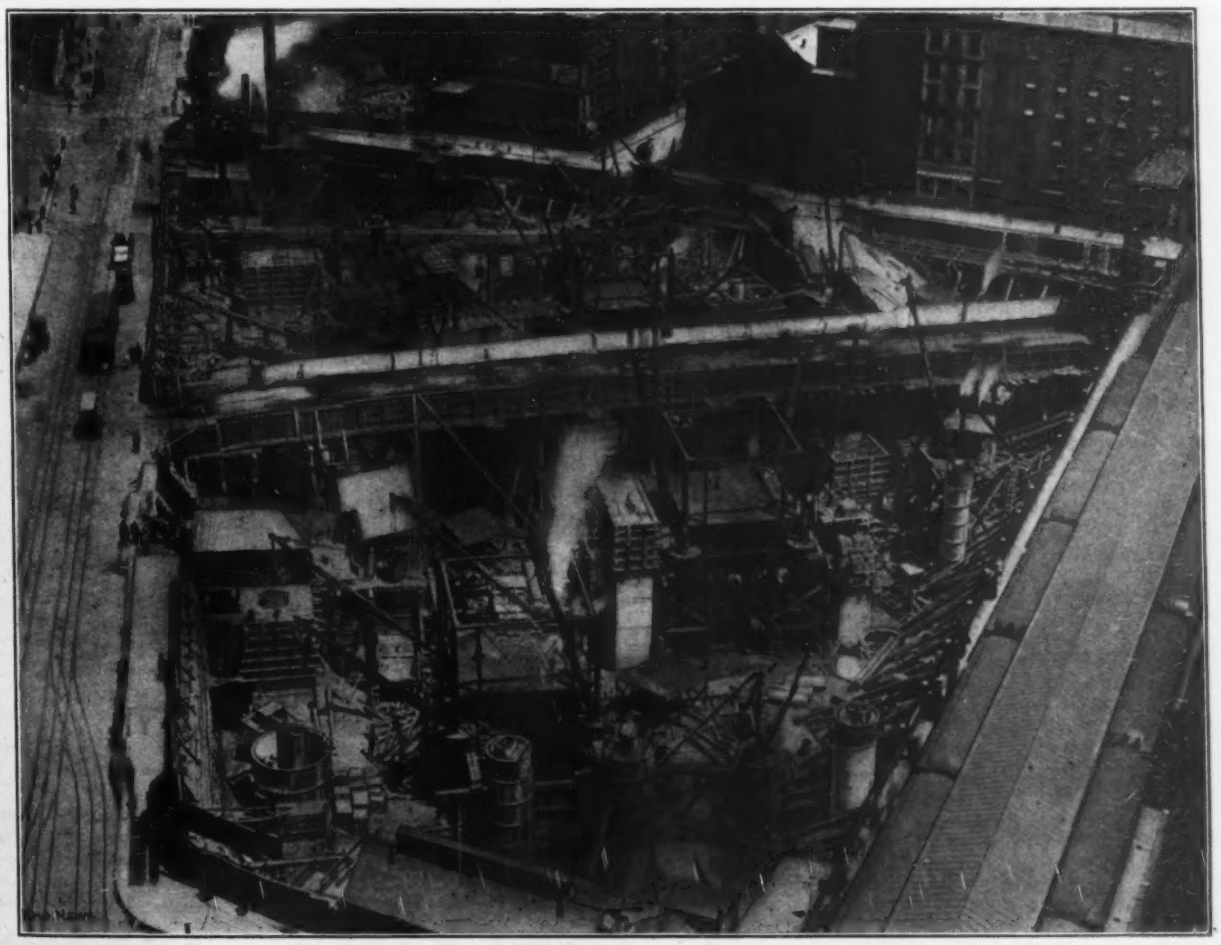


FIG. 4. MUNICIPAL BUILDING FOUNDATION WORK IN PROGRESS.

showed rock (or boulders) to lie about 100 ft. below mean high tide, apparently at uniform depth all over the site, and sand overlying. No rock cores were taken, for the reason that the data obtained from these wash borings were deemed to confirm other data as to the lay of the rock basement of Manhattan Island in this locality. On account of the great depth to rock the architects and the Department of Bridges engineers considered it proper to rest the caissons on the sand. Suitable test was made, and the actual bearing capacity of the sand at the bottom of the proposed foundation was determined to be about 20 tons per sq. ft. within the limits of a reasonable settlement. They, therefore, fixed

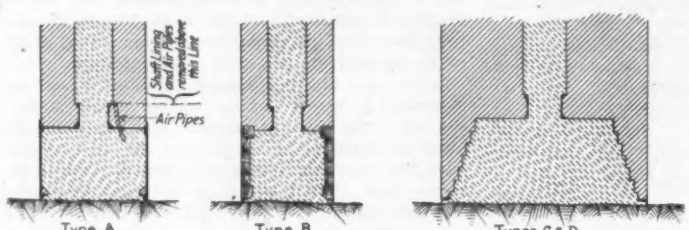

Shaft Lining and Air Pipes removed above this Line
Air Pipes
Type A.
Steel Working Chamber for small circular Caissons (6'6" to 8'6" Diam.)
Type B.
Timber Working Chamber for small rectangular Caissons (5'6" to 7'6" wide.)
Types C & D
Concrete Working Chamber for large circular & rectangular Caissons. (Circular 9' to 14'2"; rectangular 8' wide and over.)

FIG. 5. TYPE DRAWINGS OF CAISSON CHAMBERS, MUNICIPAL BLDG.

the bottom at El. — 28 (about 60 ft. below street level), and adopted a base pressure of 8 tons per sq. ft., including weight of caisson less buoyant effect of groundwater.

At this stage a question arose between the Department of Bridges, which under a special act of the State Legislature authorizing the building had supervision over its construction, and the City Bureau of Buildings (a Bureau under the Borough President). The Building Code of the city specifies a maximum foundation pressure on "firm, coarse sand, stiff gravel or hard clay," of 4 tons per sq. ft. The Bureau of Buildings therefore objected to the high pressure of 8 tons as unsafe, and refused to approve the plans. The matter was taken to court, and the courts decided that the Bureau of Buildings had no jurisdiction, except to receive the plans for filing.

Meanwhile, however, opposition to the 8-ton loading and to the proposal of founding so large and important a building on sand had been developed through the newspapers, with criticisms of the architects and the Department. The plans were, therefore, changed to provide for carrying the foundations to rock.

ROCK FOUNDATIONS.—The plans and specifications were revised on the basis of 15 tons per sq. ft. on the rock footing. Bids were received, ranging from something over $1,000,000 to over $2,000,000. On June 2, 1909, the lowest bidder, The Foundation Company, entered into contract with the city. The contract fixed the sum of $1,117,777 for the pneumatic caisson work, assuming the caissons to go down not deeper than 96 ft. below mean high water, and provided for paying for work below this level on a cubic-yard basis ($25 per cu. yd., on an estimated quantity of 6,000 cu. yds.); there was also an item of $175,370 for general excavation, sheeting and an incidental portion of the retaining walls.

The contractor at once started a series of core borings on the lot to obtain additional information on depths and nature of materials. The third hole sunk, at the northerly end of the site passed a boulder at the elevation shown on the plans and did not strike rock until a depth of 178 ft. below tide level was reached. Pneumatic work at this depth was out of the question, since the nature of the ground was such as to require probably a pneumatic pressure fully equal to the hydrostatic head. Yet the contract specified the pneumatic process and sinking to rock.

On this discovery the Department of Bridges started a comprehensive set of core-drill borings, intended to cover the whole site. As set forth in our issue of Jan. 6, 1910, these borings yielded a rock profile sloping down from the uniform level which prevails over the southerly half of the site, to a maximum depth of 160 to 180 ft. at the northerly line of caissons. It was recognized that a modification of contract was unavoidable. Methods of sinking to rock by other methods than pneumatic work were considered, but were not thought practicable. The conclusion was reached that nothing remained but to revert to sand foundation. However, work had already gone ahead on the caissons of the southerly two-thirds of the lot, where rock lay at the originally anticipated depth. The simplest expedient therefore seemed to be to leave the tower and southerly wing of the building on rock and place the northerly wing on sand.

Expert opinion was obtained as to the propriety of founding part of the building on sand while the major part was founded on rock. The reports united in approving this proposal, and approved also the suggested base depth of 40 ft. below mean high water (72 ft. below curb), and loading of 6 tons per sq. ft. on sand. A supplementary contract was therefore drawn, on this basis, in cooperation between the Department and the contractor. The approval of the Board of Estimate under which the building was designed and the ratification of the present Board having been obtained, it was formally signed on Feb. 24, 1910.

One of the sand caissons was subsequently loaded by applying sinking weights at the rate of one ton per square foot for each 24 hours until a total load of 6 tons per sq. ft., was reached; the settlement recorded after careful observation was 0.042 ft. Six days later no further settlement was observed, and the load was then similarly increased to 10 tons per sq. ft.; for the total load a total settlement of 0.079 ft. was observed, and no further settlement occurred thereafter. The test caisson has a total area of 90.8 sq. ft., is circular in plan and rests on fine sand at El. — 40.67 ft. The other caissons in this group rest on coarse sand and are generally rectangular in plan.

TERMS OF REVISED CONTRACT.—The basis of the new contract was the fact that, as the sand caissons were required to be of larger area than the rock caissons which they replaced, the saving of depth was about balanced in cost by the increase of area, so that the estimated cost was not materially changed. The revised caisson layout showed it to be expedient to replace the 48 caissons affected by 38 caissons of larger size, some of the original ones being combined by coalescing as the area was enlarged. In our plan Fig. 3, both the original rock and the revised sand caissons are shown, the latter by full lines and the rock caissons by dotted lines, for the northerly (left-hand) part of the site.

The contract of modification provides:

> For all the work to be performed [above El.—96.—Ed.] the contractor shall not receive and the City shall not pay any greater or additional amount than $1,117,777, which said amount would have been payable if the work called for under the original contract had been performed.
>
> In case it is determined by the engineers of the Departments of Bridges and Finance that the work to be performed and completed as herein described has cost less to the contractor under the agreement as hereby modified than the work would have cost to the contractor under the original agreement, the said contractor will render and pay or allow to said City the amount saved by this modification of the original agreement.
>
> For the purpose of making progress payments for work done under this modified contract, the amount of money which the contractor was to be paid for the 48 caissons which are to be eliminated from the work was $347,916.
>
> By reason of this modification of contract, the day of the completion of the work is hereby extended 90 days, to Aug. 1, 1910, the contractor will waive all claims for damages caused by delays or otherwise growing out of said contract, and hereby releases the City from all claims for damages caused by delays or otherwise which have grown out of said contract to date.

This unusual modification of contract is noteworthy also for setting forth in detail the items of cost which are to be kept account of in determining (1) the immediate cost, or labor and material cost; (2) the overhead charges, for operating plant and maintaining air, which are to be averaged per day for the time between date of modified contract and date of taking air off last caisson; and (3) the general expense. The latter is taken to amount to 10 per cent of that part of the contract, or $111,777.70, and from this is determined the charge per day, on the basis of the original contract period (611 days).

Allowance is made to the contractor as follows: The immediate cost per cubic yard for caissons sunk to rock, subsequent to Feb. 24, is taken as the direct unit cost of the caissons eliminated; from the total original direct cost thus determined will be deducted the actual direct cost of the enlarged caissons substituted, and overhead and general expense will be allowed for the number of days of the extension of time actually used to complete all the caissons. In addition, an allowance of $7,907 is made for material and work done under original contract, which cannot be used under the modified contract. Should the total new direct cost thus determined be less than the total original direct cost of the caissons eliminated, the contractor agrees to allow the city the difference as a deduction from the contract price by reason of modification of contract.

Caisson Construction.

In view of the large size of many of the caissons, the contractor decided to use reinforced concrete as material for the working-chambers, wherever practicable. The smaller caissons would not permit of the thick walls required with concrete, as their working-chambers would have been reduced too much for efficient digging and handling of spoil. But for the larger caissons concrete seemed desirable because it resulted in making the whole pier a single solid mass of concrete, of full carrying capacity and assured permanence. Moreover, the concrete caissons could be built on the ground, and this eliminated hauling the completed working-chambers.

The smaller caissons are of two types: (1) wooden working-chambers used for rectangular caissons of least width 5 ft. 6 ins. to 7 ft. 6 ins.; (2) steel plate working-chambers, used for

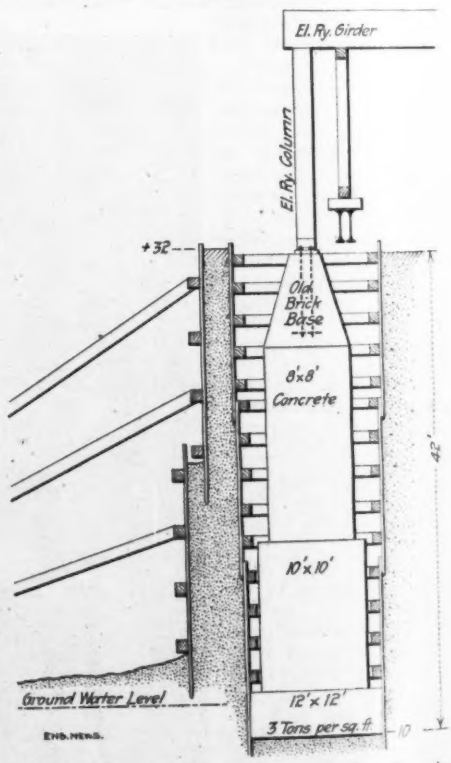


Fig. 6. Sketch of Construction of New Foundations for Elevated Railway Columns in Park Row.

circular caissons of diameters 6 ft. 6 ins. to 8 ft. 6 ins. The larger caissons are mostly rectangular, but a number of them are circular; all these are formed of concrete. The diagram, Fig. 5, shows the types and the limiting dimensions.

It may be remarked that the largest caisson is 26 ft. × 31 ft., and carries six columns with

a total load of about 5,000 tons. This is in the sand base section. It is thought to be the largest caisson ever sunk in a foundation for a building. The smallest caisson is the 6 ft. 6 in. circular, of which a number is included in both the sand and the rock sections.

The timber and steel working-chambers follow conventional patterns, except that the roof

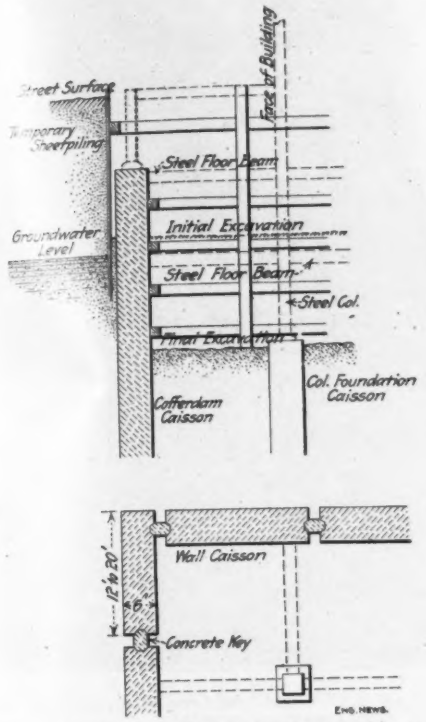


Fig. 7. Application of Caisson Cofferdam Method to a Building Foundation.

of the timber chambers is formed directly by the concrete body of the caisson shaft. The wooden chambers are generally small enough to require no internal bracing, so that the walls consist simply of tiers of 10 and 12-in. timbers spiked together and calked; a 12-in. timber faced with a 4 × 4-in. angle forms the cutting-edge. The steel chambers (circular) are stiffened just above the cutting edge by an internal trough-like flange filled with concrete.

The concrete working-chambers are characterized by stepped thickening of the walls, from cutting edge up to roof. This arrangement was chosen in preference to a tapered inner face, because it gives a reliable seating connection between the chamber shell and the filling concrete (after the caisson has reached rock and the filling proceeds), thereby assuring that the full cross-section of the finished pier has level bearing and thus is wholly available for carrying the load. The bottom edge of the wall has a width of about 10 ins., and its extreme cutting edge consists of a steel channel and a 4 x 4-in. angle, the latter forming the real cutting edge. The air is thus retained to a level 4 ins. below the bottom of the concrete wall.

There are horizontal and vertical reinforcing rods in the concrete walls, as extra security against all cracking tendencies; these rods extend up through the pier. The cutting-edge angle also is anchored up into the concrete by rod anchors.

AIR-SHAFT AND LOCK.—The shaft cored up through the pier is formed by a collapsible casing of riveted steel sections, bolted together through facing flanges. It has elliptical horse-shoe or circular cross-section, depending on the dimensions of the caisson. The style and details have been in use by the Foundation Co. for some time past. At the bottom the shaft lining foots upon a 2-ft. ring of fixed lining, with outstanding flanges, which is permanently concreted in the roof of the working-chamber; the ring is held in the concrete by the flanges and supports the shaft weight or sustains the tension due to the air pressure without reliance upon friction. At the top the shaft projects above the pier concrete and carries a vertical cylindrical air-lock of the Moran type.

MORAN LOCK.—The lock has self-adjusting swinging doors, carried loosely on a quadrant which in operation revolves the door laterally and down against the side wall of the lock. The lower door has no rope opening, and is central to the shaft below. The upper door is set with its edge on the center line of the shaft, and is recessed and bushed on this line for giving passage to the bucket-rope when closed. The lock operates as follows: To lower the bucket into the caisson, the lower lock door is closed, the upper door opened, and the bucket (carried on a derrick rope) is lowered into the air lock. As the door is off center, the bucket is now not over the shaft. But as the upper door is swung shut, its edge crowds the bucket rope over and finally engages it in the bushing, at which time it will be central to the shaft. Then the bottom door is opened and the derrick lowers the bucket down to the bottom of the chamber.

The air pipes to the working-chamber pass down from a valved connection in the side of the air-lock, along the outside of the shaft lining. A chase is cored in the concrete outside the lining large enough to accommodate the air and exhaust pipes, to the level of the bottom of the removable lining. From here the pipes pass diagonally down through the roof concrete to valved outlets at the top of the working-chamber. The short sections of pipe in the roof are anchor sections, and cannot be recovered, but the pipe above is taken out after the shaft and linings is removed, after the operation of concreting the working-chamber and prior to concreting the shaft-well.

BUILDING THE CAISSONS.—To simplify the sinking operations it was desired to construct the concrete pier of each caisson in as few separate concreting operations as possible. For the rock or 100 ft. caisson, three stages were chosen; the earth caissons being somewhat less than 40 ft. high, were generally built up in one stage. The greatest height of shaft in one build-up was about 60 ft., this being on a second build-up; the usual limit to the first build-up was about 30 ft.

It is found possible to carry this amount of top weight in the sand of the Municipal Building site without much danger of getting the caisson out of plumb in the early stages of sinking. At the same time the average amount of extra loading by cast-iron weights is reduced by building the pier up to a maximum permissible height above ground. In spite of this, very heavy iron loading had to be used in most of the caissons, as noted below.

The working-chamber and the first build-up of its superincumbent pier were constructed at ground level directly on the spot where it was to be sunk. The cutting-edge ring was set level, forms (wood or steel) were set in place, and the working-chamber was cast in one operation. Then the shaft lining, air pipes and chase mold were set up, and the pier build-up cast in one or two sections, depending on the length of outside form at hand. The structure was then allowed to age a minimum of four days before sinking was begun.

All caissons were ditched or excavated down to water-level without air (a depth of 5 to 8 ft.). Air was then put on and sinking continued, with cast-iron loading, if necessary, until the top of the concrete neared the ground surface. Then the second build-up was made, lapping the form 2 ft. on the old concrete. A temporary door was bolted on the bottom of the shaft to retain the pressure in the working-chamber, the air-lock was removed, the shaft lining and piping extended, and the concrete carried up for 30 to 35 ft. more.

In making the final build-up, it was important to keep the concrete down below the height corresponding to the final pier level, as otherwise extensive cutting of concrete would be required to get back to footing level. The borings gave a fair guide to the depth of rock, at least over the southerly half of the lot, and by making an allowance of 4 to 6 ft. a sufficient margin was usually had to take care of an upward variation of the rock surface. However, irregularities in the rock surface, in some cases showing a difference of elevation of 5 to 8 ft. within the area of a single caisson, made the estimate of height approximate at best, and several caissons had to be cut off after rock was reached.

As the footing level was several feet below bottom of ground, a length of cofferdam or form had to be bolted on the top of the pier as the caisson was sunk to final position. Placing the grillage beams and finishing the concrete to footing level was left to the contractor for the superstructure, though when the pit left was an obstruction to work nearby it was temporarily filled with sand.

FIG. 8. VIEW IN EXCAVATION OF U. S. EXPRESS BLDG., CHURCH AND RECTOR STS., NEW YORK, SHOWING CAISSON COFFERDAM AND BRACING.

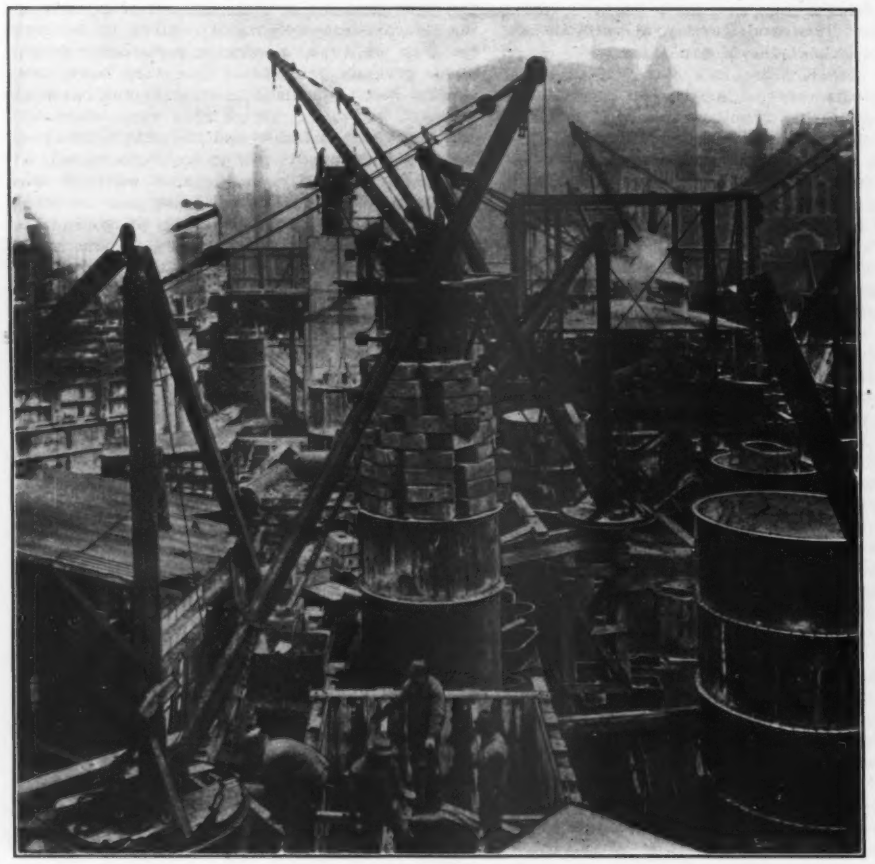


FIG. 9. SINKING AND CONCRETING.

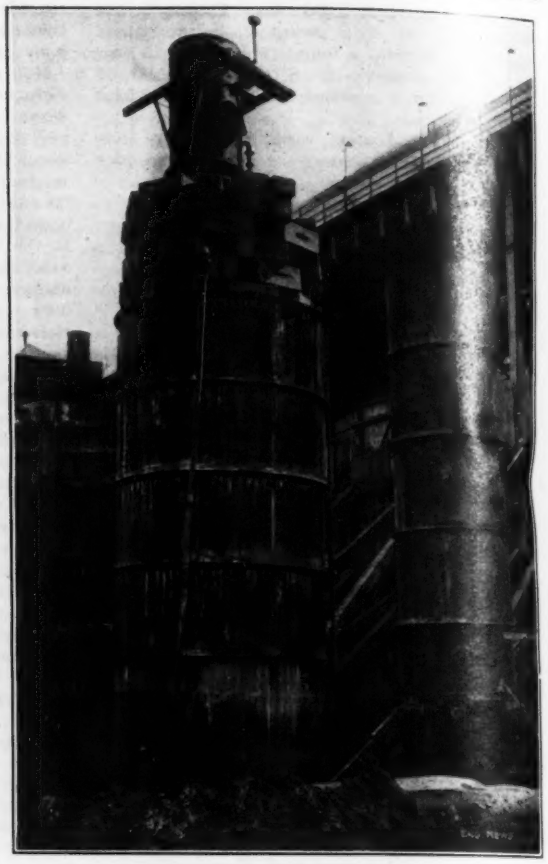


FIG. 10. TWO OF THE CIRCULAR CAISSONS; FORMS FOR CONCRETING IN PLACE.

Sinking the Caissons.

The nature of the ground permitted the sinking to proceed very regularly and without interruption by water influx or bad soil. There was an unusual amount of trouble from hanging of caissons, in part due to the fact that many caissons were close together. "Blowing," i. e., reducing the air pressure in the caisson suddenly, to give an abrupt sinking impulse, was resorted to, as in nearly all foundation caisson work, but generally only to the extent of 4 to 5 lb. reductions, within which limit the engineers of the Department of Bridges found no objection to the procedure.

In one instance a caisson 8 x 28 ft. hung when the cutting-edge was about 5 ft. above rock, and cast-iron loading of 1,000 tons was insufficient to start it. The skin area at this time was a trifle less than 7,000 sq. ft., and the air-pressure about 45 lbs. In this instance another caisson was only 6 ft. distant. Iron weighting was required for practically every caisson, and the amount of nearly 3,000 tons of weights kept on hand was often hardly sufficient.

The compressed air, supplied from a central station erected in the vacant space just north of the site, was reduced to the pressure needed in the caisson by hand valves, on the ground alongside. A steel supply pipe led to the valves, and from here a duplicate hose carried the air up to the valved nipple at the air-lock. An air tender was stationed constantly at the valves, prepared to increase or cut down the supply as might be signaled by the digging foreman in the caisson.

BOTTOMING.—When a caisson grounded on the rock, generally little more was required than to clear off the rock-surface and remove loose material. In those caissons where the surface sloped, the rock was cut down to the level of the lowest point, to give a level base. In this work dry cement was used successfully to seal the exposed face of earth against loss of air.

To determine whether the bottom was satisfactory for concreting was the duty of a specially-retained expert inspector, Mr. T. K. Thomson. The amount of rock to be removed, the shaping of the surface, etc., were subject to his direction.

RATE OF SINKING.—The best index of the satisfactorily rapid progress of the caisson work is the completion of the entire contract in 15 months. The total number of caissons sunk was 106 (68 to rock, 38 in sand to El.—40). Thus the average output was 7 caissons per month. Roughly stated, 6 to 8 were in progress at a time, and the gross sinking time per caisson was something under one month. The best long-continued rate of sinking was about 4 ft. per day; the average was about 3 ft.

The most rapid completion was recorded for one of the small (6 ft. 6 in.) cylindrical caissons in the northeasterly corner of the lot, which was sunk to El.—40 in 24 hours from the time compressed air was applied. This caisson had been constructed in a single build-up. The rock caissons, all of which required two or three build-ups,

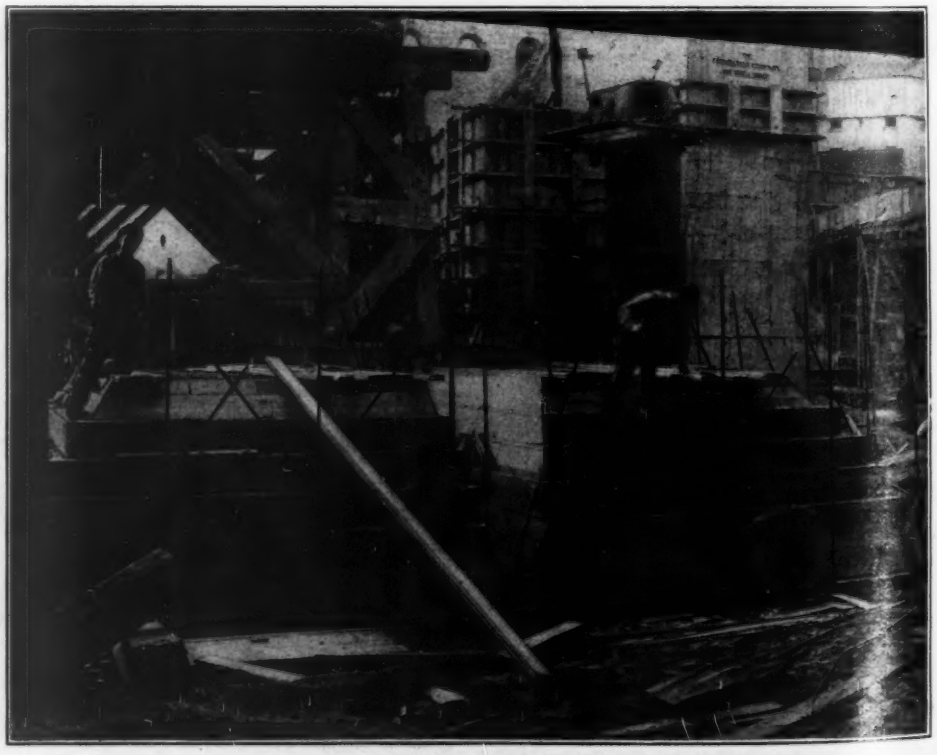


FIG. 11. INSIDE FORMS FOR WORKING-CHAMBERS OF A LARGE CONCRETE CAISSON WITH DIVIDING WALL.

required more than one month each. Probably the best record was made in the deepest caisson, sunk to El. — 114.66 ft., in a total time of 40 days.

The maximum air pressure used was 48 lbs. on the gage in the caisson. At an early stage of the work two separate trials were made to expedite and cheapen the pneumatic work by pumping down the groundwater. Caissons were sunk about 30 ft. into the sand, and the working chambers partly filled with gravel to form strainers. Pumping from these "wells" had to stop after two days, because the water gave out. Test holes were put down at different distances from the "well," in each case, showing that at 80 ft. distance the groundwater had not been appreciably affected. The second attempt, made with more thorough care than the first, failed in the same way, and thereafter the idea was considered impracticable.

Working Plant.

The compressor plant was placed in a shed at the north end of the site. It was arranged for ample power and continuous operation; 14 boilers aggregating 1,800 HP. were installed. They furnished steam to seven compressors, which were taxed to full capacity throughout the work: 5 Ingersoll-Rand, 22 & 26¼ x 24-in. stroke; 1 McKiernan, 22 & 26 x 24-in. stroke; 1 Ingersoll-Rand compound, 18 & 30, 22 & 22, x 24-in. stroke. Two sets of twin air-cooling receivers were provided to take the discharge from these compressors. The maximum pressure required in the caissons being about 50 lbs., the main receiver was kept at about 60 lbs. during the entire work, except in the earliest stages of the contract. This gave about 54 lbs. on the gage at the valve alongside the caisson. A separate receiver was kept at 20 lbs. for the work in the north end of the lot. The 60-lb. air was used also for rock drills and a hammer. Because of the high pressures the contract specifications (and after 1909 also the amended New York labor law) required that a hospital lock be maintained at all times, with physician in attendance, and a room fitted with shower baths, lockers for clothing, etc. The hospital lock was set up in the "sand-hog" house under the Chambers St. bridge. It was a two-room lock very similar to those used in connection with the Pennsylvania R. R. river tunnels. The inner room was heated by steam and fitted with cot beds.

There was little trouble from bends during the work. The provisions of the new State law governing compressed-air work are very stringent, and limit the shifts and time of decompression as follows:

Pressure.	Hours labor per day.	Rest period in middle of labor period.	Rate of decompression.
Atm. to 28 lbs....	8	½	3 lbs. in 2 min.
28 to 36 lbs....	6	1	
36 to 42 lbs....	4	2	1 lb. per min.
42 to 46 lbs....	3	3	
46 to 50 lbs....	2	4	

No work in pressures over 50 lbs. except in case of emergency.

The hoisting plant comprised twelve derricks on two four-derrick steel travelers, and one four-derrick wooden traveler, 13 stiff-leg derricks, and one jinnywinch. The maximum number working at a single time was 21 booms. The bucket equipment included 22 caisson dirt buckets, 10 caisson concrete buckets, and 24 buckets for outside use, of ½ and 1 cu. yd. capacity. There were three electric pumps and nine steam pumps in the plant; they gave an ample capacity, with reserve. Six concrete-mixers, of ¾ and 1 cu. yd. capacity were required. A stock of 2,475 tons of cast-iron weights was kept on hand; these were in 1-ton and 1¾-ton sizes, the former making up about two-thirds of the stock.

The arrangement of the plant varied constantly as work shifted from one caisson to another. The sequence of caissons and location of derricks were so chosen as to call for the least amount of shifting of derricks. The travelers, running along the middle of the lot, were the center of the work in the first part of the period.

The work described was done by The Foundation Co., of 115 Broadway, New York City, under the direction of the city's Department of Bridges, Mr. K. L. Martin, Commissioner, and Mr. A. Johnson, Chief Engineer. McKim, Mead & White were architects to the city. Mr. F. W. Perry was Resident Engineer for the Department of Bridges. Mr. S. J. Munro was Superintendent for the architects. Mr. L. L. Brown, General Superintendent of the Foundation Company, was in general charge of the work, and Mr. W. S. Downing was the company's Superintendent in direct charge.

The Barren Jack Masonry Dam in New South Wales.

There is now under construction on the Murrumbidgee River in New South Wales a masonry dam for irrigation storage purposes which ranks among the large storage dams of the world. This structure, known as the Barren Jack Dam, is being built by the Government of New South Wales under the direction of Mr. L. A. B. Wade, M. Inst. C. E., Chief Engineer for Rivers, Water Supply and Drainage of the Public Works Department.* From a recent article in "The Engineer" of London, and from other data at our command, we are able to give the following description of the dam, which, it is expected, will be completed in the fall of 1913.

As is shown by the accompanying table, the Barren Jack Dam is very similar in design and dimensions to the Roosevelt Dam, recently completed on the Salt River Project of the United States Reclamation Service.

	Roosevelt	Barren Jack
Length, ft.	700	784
Max. hgt., ft.	276	240
Max. water depth, ft.	242	224
Crest width, ft.	16	18
Down str. batter	3:2	3:2
Up " "	20:1	20:1
Storage, acre ft.	1,284,000	785,000
Material	sandstone	concrete
Radius to inner face, ft.	abt. 400	1,200

As originally designed, the Barren Jack Dam was to be 910 ft. long at the crest and curved against the water pressure to a radius of 940 ft., and having a total height of 232 ft. A better site in the same gorge of the river was afterwards fixed upon, and the design now calls for a length of 784 ft., with a curve of 1,200 ft. radius and a maximum height of 240 ft. The structure is described as follows in "The Engineer":

The dam is of cyclopean concrete with "plums" of the granite of which the sides of the gorge are formed. The base of the dam is 163 ft. wide and 20 ft. high, with vertical sides. At this point the gravity section begins with a width of 145 ft., the reduction being wholly at the down-stream side. Above this base the up-stream face has a batter of 1 in 20, and the down-stream one slopes at 1 horizontal to 1½ vertical up to 60 ft. below crest. Above this the upper face is curved to a gravity section so as to finish with a width of the dam at top of 18 ft. The maximum depth of water behind the dam will be 224 ft., and the capacity, which approximates to that of the Aseuan dam before it was raised, will amount to 33,380 millions of cubic feet. The catchment area embraces 5,000 square miles, mostly of hard shale formation, and much of it mountainous, which is snowfed in winter. The outlet will be by a tunnel, 14 ft. 3 in. by 13 ft., controlled by valves worked in the usual way by gearing from a masonry tower standing out up-stream from the body of the main wall. The outfall will be further controlled by a second set of valves near the chamber contained in the body of the dam, and approached from the upper platform by a ladder shaft and tunnel. Provision for overflow in the event of the capacity of the reservoir being overtaxed by an unusual rainfall will be made by two by-washes, 400 ft. long and 25 ft. wide and splaying out, one at each side, the ends of which will be kept away from the toe of the dam, which might otherwise be injured by the wash so produced.

The sand required for the concrete, &c., is obtained from a distance of about three miles, and is conveyed by a specially constructed narrow-gage railway. As the site of the dam is 26 miles from the main line of railway, a 2-ft.-gage line, built for the purpose, and now over two years in operation, conveys the cement and other materials to the work. The whole of the machinery in use on the works is driven electrically from a central power station, in which are installed four generators having a total output of 700 amperes at 500 volts. Local wood fuel is used. Lidgerwood cableways, which have a span of 1,200 ft., with a capacity of 15 tons, at 250 ft. per minute, and several 10-ton electric cranes are in use.

*See Mr. Wade's description of other curved dams built in New South Wales in Engineering News, May 19, 1910, p. 588.

The foundations of the dam have been found highly favorable. After the gravel had been removed solid water-worn granite showed from bank to bank without flaws or defects of any description. The action of the water had worn the granite into most curious shapes, pot-holes in places having been cut to a depth of several feet by constantly revolving boulders. This formation provides a sort of key to counteract any sliding effect of the water pressure on the dam.

The extraordinarily favorable site of the dam, and the proximity of suitable materials, will cause its cost of about $4.70 per acre foot of water stored to be one of the lowest on record, the Roosevelt dam in Arizona being the only large one which is much more favorable in this respect. It is stated that 5,000 HP. will be available for electric power, and as the dam is only 36 miles from the new capital city of Australia, it is possible that in the future the Barren Jack power, may be utilized there in addition to that of the water supply already designed for the proposed town.

A question has arisen, as to the advantage of curving the Barren Jack dam in plan to add to its strength, seeing that a sufficient gravity section has been provided, and that apparently greater length, and therefore larger quantities, were involved in order to obtain this superfluous security.

On the ability of the dam to resist pressure due to its cross-section alone and to its material, we may quote here the evidence of Mr. Stuart Murray, M. Inst. C. E., before the New South Wales Parliamentary Committee when the project was being considered. He said:

The resultant lines of pressure for reservoir full and reservoir empty fall well within the middle third of the base. . . . The computed maximum pressures on the foundations are at the inner toe 15 tons* and at the down-stream talus 14.2 tons per sq. ft.; whilst the ultimate resistance to crushing of concrete made from the available material and according to the specification adopted is, from the results of tests made at the Sydney University, 180 tons per sq. ft. The factor of safety in strength is therefore 12, that usually deemed indispensable in such works being from 8 to 10. The resistance to overturning is found by comparing the resultant of the maximum water pressure against the face of the dam by the weight of its mass, multiplied in each case by the leverage under which it acts. The maximum pressure against a lineal foot of the dam at its highest point is 737.16 tons, acting at 76.66 ft. above the level of its base. Hence the overturning moment is equal to 56,515.6 foot-tons per lin. ft. The moment of stability of each lineal foot of the dam at its greatest height is 1,178.5 tons, the weight of the section acting at the center of gravity, which is distant horizontally 103.63 ft. from the down-stream toe. It is therefore equal to 122,128 foot-tons, and the factor of safety in stability is 2.16. That is, the resistance to movement of the mass is 116% in excess of the overturning moment.

This being so, it was natural to raise the question of the advantage of the curvature, but Mr. Wade, the designer of the dam, wrote in the discussion referred to that the configuration of the sides of the gorge at the site was such that the quantities in the flanks of the dam had not been increased by the curvature given to the wall.

When the dam is full the main river will be backed up for 40 miles, and two important tributaries, 24 miles and 19 miles, respectively. These consequences involve diversions of roads, reconstruction of bridges, &c., and, including the 26-mile material railway, account for the total estimate for the dam at $3,680,000. It is not intended, however, to wait for the completion of the work to put it to use, and the building contract, which was entered into in February, 1909, provides for the wall reaching the height of 110 ft. in August, 1911, when storage will be begun, so as to ensure irrigation in the summer of 1911-12. The remainder of the dam is to be finished in August, 1913.

A WINDOW-LOUVER has been invented to replace large pivoted windows in ventilators or monitors in factory or warehouse buildings. The ordinary louver has fixed slats of wood or steel which admit only a very little light. Among the advantages claimed for the new device as compared with a large pivoted window are less surface exposed to the weather, when opened, and less cumbersome operation.

In the window-louver, the slats of the ordinary louver are replaced by narrow windows, with panes 8 ins. wide. The length of these window-slats may be anything up to about 6 ft. Each slat is pivoted at each end on ½-in. round pins driven through the mullions. The separate slats are connected at one end to a vertical bar, which can be raised or lowered by a man on the floor by means of a rope and pulley. Thus the louver slats can be closed or opened as desired. The operation is very similar to that of an ordinary window-blind.

Two modifications of the operating mechanism are provided. The first permits only two positions of the window slats—wide open and tightly closed. In the second, the vertical bar connected to the slats is threaded at the upper end and engages a nut which is also a worm wheel. The worm wheel is driven by a worm keyed to the pulley shaft. By turning the pulley the nut is revolved and the vertical bar raised or lowered. With this arrangement the slats are held positively at any desired opening. The inventor is Mr. H. von Wagner, Oakmont, Pa.

*Long tons of 2,240 lbs.

The Siphon Lock on the New York State Barge Canal at Oswego, N. Y.

By D. A. WATT,* M. Am. Soc. C. E.

There has been recently completed and put into daily service at Oswego, N. Y., a lock of a type which is new to the United States, although it has stood the experience of several years in Germany. This lock was built in connection with the work for the new Barge Canal of the

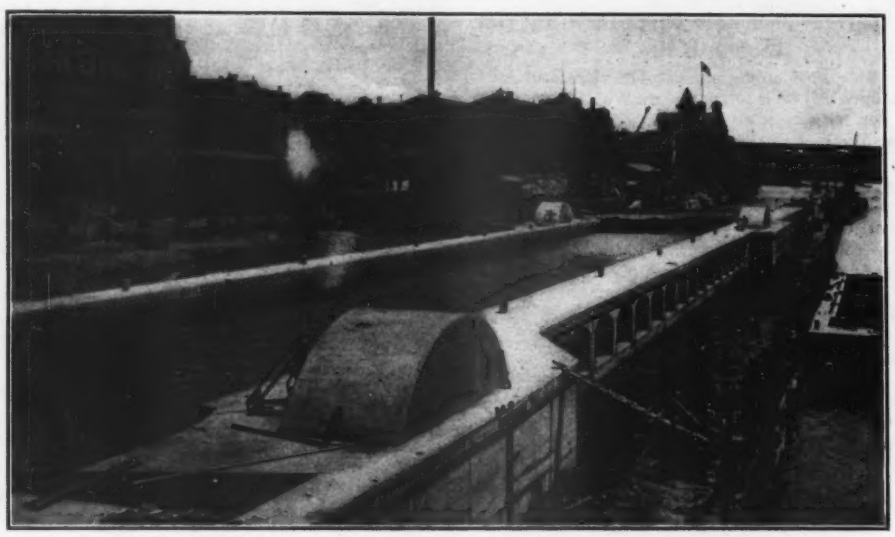


FIG. 1. VIEW OF THE SIPHON LOCK ON THE NEW YORK STATE BARGE CANAL AT OSWEGO, N. Y.

State of New York, and is the last one of the series along the Oswego River. It connects Lake Ontario with the first level of the new canal above. The lock is of the siphon type, the filling and emptying of the chamber being carried out by means of culverts whose upper and lower ends are formed into siphons, the flow of water in them being started and stopped by the regulation of the air.

The first lock of this type was completed about 1896 at Krummesse on the Elbe-Trave Canal which runs southward from the port of Lubec in North Germany. It was desired on this canal to reduce as far as practicable the loss of water by leakage through valves, etc., as well as the expenses of maintenance and operation. Plans were accordingly prepared under the supervision of Prof. Hotopp for locks which should be filled and emptied through culverts operated on the siphon principle, and with lock gates which should be operated by means of compressed air obtained from the natural fall of the water. Various experiments were made prior to the building of the first lock so as to determine the several proportions necessary, and to obtain information as to practical points which the working of the system might develop. As the lock proved satisfactory the remaining locks on the canal, six in number, were built on similar principles. The available length of the chambers is about 262½ ft., with a width of 56 ft., reduced at the gates to 39 ft. 4 ins. The least depth on the miter sill is 8 ft. 3 ins., and the lifts range from 5.2 ft. to 13.75 ft. An extreme lift, however, of 18 ft. sometimes exists at the lock at Lauenburg during low water stages on the river Elbe.*

Since the completion of this system a few other locks of the siphon type have been built in Germany, as on the Teltow and Oder-Spree Canals. In these locks the culverts are built as siphons, but the lock gates are operated by ordinary mechanical devices.

Briefly described, the operating principle comprises a culvert in each wall, the portions near each end being turned up to form a closed siphon as indicated in Fig. 2. The crown of each siphon communicates by means of pipes with a tank placed high in the wall, arrangements being made to fill the tank from the upper pool when required, as well as to empty it into the lower pool. After the tank has been filled it is shut off from connection with the upper pool and with the outer air, and the emptying valve is then opened. This has the effect of suspending the water in the tank, so to speak, and thus creating a tendency to vacuum. On connecting a siphon with the tank, the air is drawn out of the former and the water rises over the crest and soon fills the neck. When it runs full it reverses the draft, and draws the air back from the tank and carries it out with the flow, filling the tank again and restoring the vacuum automatically. The flow in the siphon can be checked or stopped at any moment by opening a small valve communicating with the outer air.

One of the locks of this type in Germany, was examined in 1905 by the writer and as it appeared to possess several advantages in simplicity and economy of operation and maintenance, it was recommended to be one of similar construction for the Barge Canal wherever conditions might be most favorable. These were found to exist at Oswego, where the lower lock of a series of two was to connect with Lake Ontario, assuring at all times a moderate lift without much variation in the upper water level. The method of operating the lock gates by compressed air, as is done on the Elbe-Trave Canal, was not adopted as it did not appear to possess the merits of simplicity to the same extent as did the siphons, and as the lock gates were to be of considerable size and weight the method would have required arrangements in the construction which might have proved cumbersome.

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*For additional information regarding these locks and the method of operating the lock gates see "Engineering," May 4, 1900.

General Design.

In general dimensions the lock is of the standard size used elsewhere for the Barge Canal and with the exception of the siphons presents no special features. The width between walls is 45 ft. throughout; the available length is from 300 to 310 ft.; and the least depth on miter sills is 12 ft. The lift varies from about 6 ft. to about 12 ft. A variation in the upper pool level of 1 ft. is provided for to allow for the fluctuations caused by letting in or drawing out water during lockages. The highest upper level was assumed as 256.5 and the lowest as 255.5, the elevation of the bottom of the prism being designed, however, so as to afford a depth never less than 12 ft. in case the water should temporarily fall below 255.5. A lockage under a 9-ft. head causes a variation of about 6 ins. in the upper pool level. The lower pool is the level of Lake Ontario, and varies from 244.4 to 250.0; these extremes, however, rarely occur except at intervals of several years. All the masonry is of concrete and rests on a hard limestone rock which had to be excavated for a depth of several feet in order to obtain the requisite draft for navigation. The gates are of standard mitering type and built of steel. About 2,000 ft. upstream is a second lock (Lock No. 7) which affords communication between the Oswego River and the pool between the two locks.

In making the preliminary investigations for the design it became evident that if the siphons and the vacuum tanks could be built as part of the masonry a considerable saving would result. In German practice it had been customary to make the siphons of iron from water level to water level in order to make them air-tight, lining them with concrete as a protection against rust, and the vacuum tanks were also made of iron and placed in specially constructed chambers. (An exception to this is found in a siphon lock completed two or three years since on the Oder-Spree Canal where the siphons are stated to have been made of reinforced concrete.) It was believed that vacuum tanks of concrete could be made sufficiently air-tight by using a water-proof preparation on the inside, and it did not seem probable that, should any air seep into the concrete siphon necks while they were in use, it could prove objectionable since they would not be

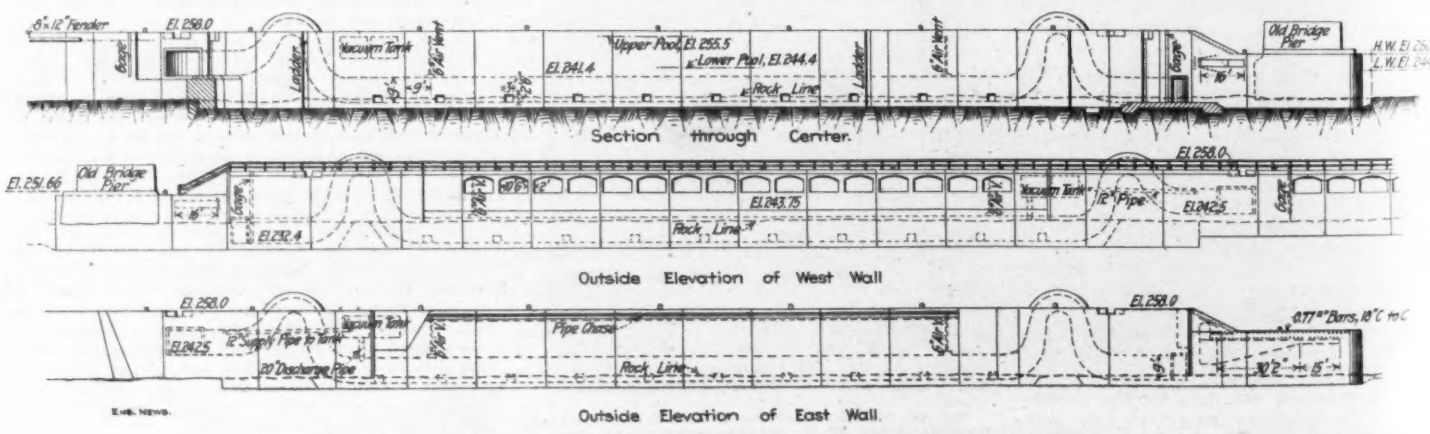


FIG. 2. LONGITUDINAL ELEVATIONS AND SECTIONS OF SIPHON LOCK.

in operation more than a few minutes at only one time.

As finally designed, the siphons are built in the general masonry for the walls except where they project above the coping, and these parts are made of reinforced concrete of proportions 1:2½:5, heavily reinforced. The vacuum tanks are similarly made a part of the masonry except where they project beyond the gravity outlines required for the walls, and these projecting portions are made of reinforced concrete of the same proportions as the siphon necks, and are also heavily reinforced. This reinforcement was made sufficient in all cases to withstand a complete vacuum.

The culverts run lengthwise of the walls, opening into the head and tail bays and communicating with the chamber by side outlets or ports. The tops of the culverts are from 3 to 4 ft. under the lowest pool levels. Each culvert is 5 ft. wide and 7 ft. high, except at the siphon necks where they are made 5 ft. square, the reduction in area being made gradually on the principle of a Venturi meter, and with the view of assuring a strong draft at those points as well as a reduction in the amount of air to be handled. No waterproofing of any kind was used in the siphon necks nor were any means taken to render them specially air-tight. The crests are placed somewhat higher than customary, since the upper pool must be kept not lower than the highest pool elevation (256.5) during the construction of Lock No. 7 in order to enable boats to pass over the miter sill of the old lock still in use in this pool.

The minimum depth below low water for the tops of culverts of siphon locks should, it is stated, be not less than 6 ins. to secure a proper water-seal, and the elevation of the crests of the siphons is usually placed from 3 to 6 ins. above the highest water level.

While this type of lock needs some additional concrete and introduces some complications in construction; the total cost, as compared with the expense for culvert valves and machinery such as are to be used on other locks of the canal, proved somewhat less. An approximate estimate based on the final design and compared with the quantities which would have been required for a lock or ordinary design under the same conditions, showed a saving in favor of the siphon type of something over a thousand dollars. The principal advantages, however, are found in the simpler and more economical operation and maintenance. Complications with machinery are avoided and there are no large valves to be operated under water, nor will there be deterioration of steel work under water to be reckoned with. The motive power for filling and emptying the chamber is obtained from the direct action of the head of water and is self-renewing, and the only movable parts are the gate-valves, which are easily accessible and simple in design.

The vacuum tank which supplies the motive power (if only one tank is used) is usually made of a capacity equal to the maximum volume of air in two of the siphons plus 20%. Thus at the Krummesse lock above referred to the volume of the tank is about 920 cu. ft. while the volume of two siphons gives a total of about 770 cu. ft. This one tank operates the four siphons, connecting pipes being carried under and across the head of the lock, and the air valves being placed together in one operating room. At the Klein-Machnow lock of the Teltow Canal the tank contains about 625 cu. ft., the volume of two siphons being about 530 cu. ft. The use of a single tank appears to have been convenient for adoption with all locks hitherto, but in the lock at Oswego it was found that this would require so large a tank that it would interfere with the construction, and it was accordingly decided to use two separate tanks, placing one in each wall close to the upper siphon with the air pipes leading directly to it instead of crossing the chamber. As it was desired to have ample operating power the proportion of the volume of the tanks to that of the siphons was made large. Each tank contains about 1,100 cu. ft. at low pool levels, while the corresponding volume of each siphon is about 800 cu. ft., or 1,600 cu. ft. for two. The tanks measure 7½ ft. in width, 7¾ ft. in height, and 21 ft. in length, a center partition 1 ft. in thickness being used so as to tie the walls together. The roofs are placed at average pool level (256.0). The walls are constructed with a layer of waterproofing built into the concrete, and the inside faces of the tanks are in addition coated with asphalt. This was done for the purpose of rendering the tank air-tight, but it is believed from observation of the leakage, when the water is left standing in the necks of the siphons after operation, that the precaution might have been omitted, since practically no air appears to seep in through the concrete of the necks, although these were not provided with any special coatings. The vacuum load on the roofs of the tanks may vary from about 350 lbs. to about 750 lbs. per sq. ft., corresponding to an air pressure of about 2.5 lbs. to 5.2 lbs. per sq. in.

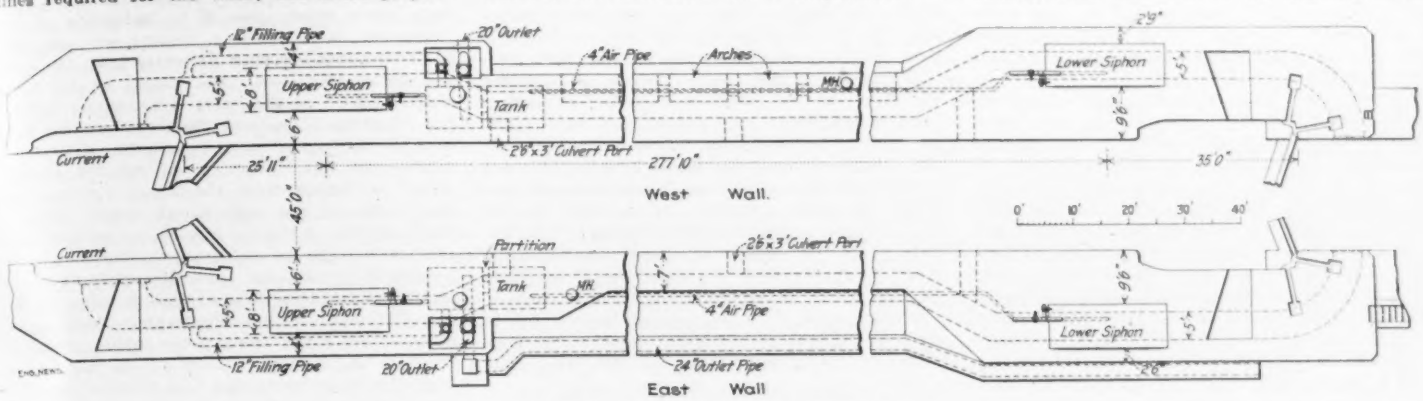
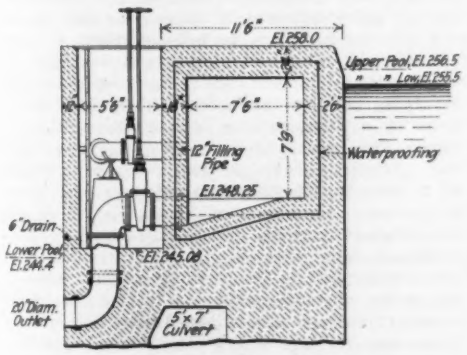


FIG. 3. PLAN OF SIPHON LOCK, OSWEGO, N. Y.



Vacuum Tank.

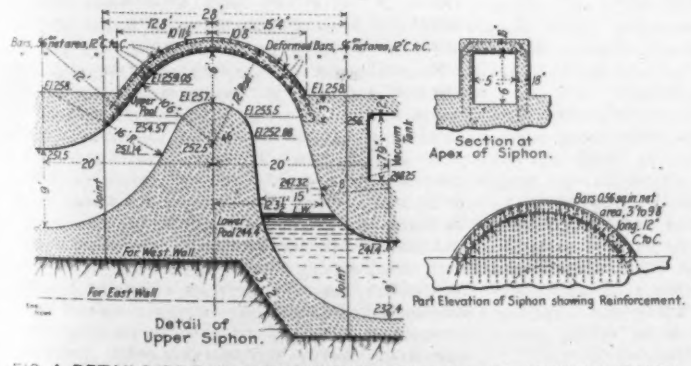

Section at Apex of Siphon.
Part Elevation of Siphon showing Reinforcement.
Detail of Upper Siphon.
For West Wall
For East Wall

FIG. 4. DETAILS OF THE UPPER SIPHON AND OF THE VACUUM TANK.

In proportioning the tanks it is necessary that the superficial area should be as great as possible in order that they may withdraw the maximum amount of air from the siphons with the minimum loss of head. If, for instance, the superficial area of a tank is made 25 sq. ft. (so that a fall of 1 ft. in the water contained therein would draw 25 cu. ft. of air from its connected siphon) and the volume of air in the siphon for a corresponding height of 1 ft. was also 25 ft., the change of head in each case for this 1 ft. would, of course, be equal. However, by making the area of the tank say 50 sq. ft., and not changing conditions in the siphon, a fall of water of 6 ins. in the tank would raise the water 1 ft. in the siphon, or to the same height as before, and the operating head in the tank would only have lost 6 ins. instead of 1 ft.

The application of this principle is very necessary where the lift is comparatively low or the amount of air to be handled is large, and by properly proportioning the tank it is practicable to cause the water to rise in the siphon neck for a considerable height while still retaining a good head in the tank. In the Oswego tanks each foot of height contains 150 cu. ft., and a fall of 0.7 ft. in the water contained therein will raise the water in the siphons 1.5 ft. at the beginning of an operation, both pools being at the low levels. A fall of 3.1 ft. will make a corresponding rise of 5 ft., and fall of 4 ft. will make a rise of 6 ft. The final height to which a tank can lift the water in a siphon, neglecting the effect of self-priming, cannot of course exceed the respective final heads; thus if the water level in the siphon is to be raised 6 ft., it must be seen that there will be a head of not less than 6 ft. left in the tank at the end of the rise.

Owing to their large size and to the amount of air in the Oswego siphons, and to the reduction of lift during high stages in the lake, it would have been difficult to have made the tanks large enough to exhaust all the air under the smaller heads. The operation at such times is secured by the self-priming action observed with closed siphons, by which when the flow reaches a certain height above the crest it will begin to carry out the remaining air and will complete automatically the filling of the neck. Information was meager as to the precise height at which this action begins, but from the authorities

available it appeared to be at one-third the height from the crest to the crown. Tests of this were made by placing a gage between the valve "A" (Fig. 5) and the upper siphon, so that by closing the valve the gage would show the amount of vacuum in the siphon at that moment, and from this the rise of the water in it was deduced. It was found that when the level reached the one-third point the self-priming began, but the effect was slow. By causing the water to rise a few tenths more, however, there was a marked increase in the speed. Information as to the time required for filling by this method is given further on.

As originally planned both tanks discharged directly into the lower pool. Some time after construction had begun, however, it was decided to permit the contractors to fill in the basin on the east side, and this necessitated extending the outlet from the tank as far as the lower end of the lock. A manhole 2½ ft. square was accordingly built against the mouth of the east 20-in. outlet pipe and connected with a line of 24-in. tile pipe set in concrete on the surface of the rock. The water from this tank consequently will have to travel when the outlet is completed about 250 ft. further than the water from the

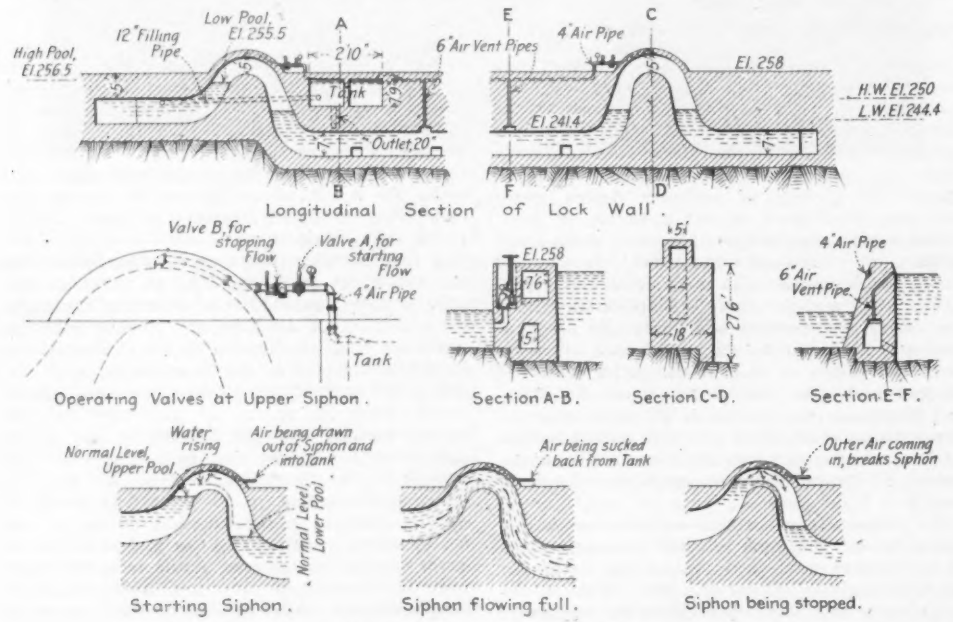


FIG. 5. SKETCHES SHOWING THE ACTION OF THE SIPHON LOCK.

west tank. At the present time the extension has been completed about 200 ft., and tests show that the change of length and direction of the outlet appear to delay the time of action of the connected siphons about one minute. There is a considerably greater difference when emptying the tank by admitting free air. Thus the time required to empty the west tank by admitting air through the upper siphon valves is 1¾ mins., while the corresponding operation for the east tank is about 5 mins. When the lower siphon valves are opened the time is about 6 mins.

The air pipes are 4 ins. in diameter, and where exposed or where entirely built in the masonry are made of galvanized iron. The portions which are partly exposed and partly built in are made of cast iron. The pipes leading from the lower siphons to the tanks are placed where they are accessible, and are provided with slip joints to care for the expansion and contraction, together with drain valves at the center so that they can be drained for the winter. In order to keep the pipes out of view they are placed in slots below the coping, each pipe being therefore below the level of the top of the lock walls for the greater portion of its length.

The valves for controlling the movement of the air are standard 4-in. brass lever gate valves, one being provided to communicate between each siphon and the tank, and another being used to communicate with the outer air. These are marked "A" and "B" respectively on Fig. 5. The latter valve is used either for breaking the siphon or for letting air out of the tank. It would have been practicable to have used single two-way valves instead of two gate valves, but this would have required a special design, and it was believed moreover that it would be less confusing for the operators to have separate valves for the different maneuvers of the siphon.

The pipes for filling the tanks with water are 12 ins. in diameter, opening from the culverts, and the outlet pipes are 20 ins. in diameter. Both of these are controlled by standard iron-body brass-mounted gate valves with screw stems, as it was desired to have a type of valve which would be air-tight and water-tight, and certain in its action. While slower in operation than valves of the butterfly type, they are only occasionally used, and it was believed preferable to adopt a design which would be free from possible complications of leakage, etc. The 12-in. valve is opened or closed by about 13 turns, occupying 20 secs.,. while the 20-in. valve takes 22 turns, occupying from 30 to 35 secs.

In order to test the amount of friction due to the long lengths of air pipe, experiments were made by filling and emptying the west tank under different conditions. With the manhole cover removed so that the air had free escape, it took 3 mins. 40 secs. to fill the tank from the time of beginning to open the 12-in. valve. With the cover bolted down and the air escaping through the valves "A" and "B" at the upper siphon 4 mins. were required, while with these valves closed and the corresponding valves open at the lower end, thus forcing the air to travel through about 250 ft. of pipe and around several bends, 5 mins. were required.

In emptying this tank similar differences were found, the time required (counting from beginning to open the 20-in. valve) with air admitted through the upper siphon valves being 1¾ mins., while 3 mins. were required when the lower valves were used. The reduced strength of the suction at the lower inlet valve was plainly noticeable. The head during these experiments was about 8 ft. This difference of about one minute is found to exist in filling and emptying the chamber, the latter operation taking about a minute longer than the former.

Operation of Lock.

The operation of the lock, described more at length, is as follows, the various devices being shown in the drawings. The tank is first filled with water from the upper pool by opening the 12-in. valve and permitting the air to blow off through the valves "A" and "B." This operation takes about 4 mins. These three valves are then closed and the 20-in. outlet valve is opened, thus producing the effect of suspending the water in the tank above the lower pool. The amount of vacuum is indicated on the gage placed close to the operating valves, and as soon as the outlet valve has been fully opened the apparatus is ready for use. To start the flow, assuming the lock is to be filled, the valve "A" is opened, putting the siphon in connection with the tank. A faint hissing is heard, lasting for a few seconds, after which there is no indication of any movement except that on looking over the edge of the wall the outflow of water from the tank can be plainly seen. The needle on the gage drops as soon as the valve is opened to a reading of about 2 ins. and remains there for one-half or three-quarters of a minute. At the expiration of this time a jet of mingled air and water is thrown from the upper air vent and the needle of the gage starts slowly upwards. Some portion of the air carried out by the water escapes through the culvert ports, but the greater portion is thrown out from the upper air vents, and towards the middle of the operation of filling the jets are of considerable violence, the mingled air spray being occasionally thrown 50 ft. from the outlet. Nearly all the air escapes from the upper vents and very little is carried to the lower ones, nor does any large amount usually escape through the culvert ports. As the discharge from these vents is considerably greater both in concentration and in amount than was expected, the directions of the outlets will be modified so as to keep the water away from boats.

After the chamber is filled, the valves "A" are closed and the valves "B" opened, letting air into the necks and causing the water to fall to the upper pool level. The time required to fill the chamber with a head of about 9 ft. ranges from a minimum of 4½ mins. to a maximum of 5 mins., the amount of water taken per lockage being about 140,000 cu. ft. The Krummesse lock with a similar head requires 7 mins., and takes about 136,000 cu. ft.

The operation of emptying is conducted similarly to that of filling. Owing to the friction in the air pipes, however, it takes somewhat longer for the lower siphon to become filled, so that the starting of the discharge is slower than at the upper end, and the whole operation of emptying requires, when the head is about 9 ft., from 5½ to 6 mins., or a minute longer than the filling. The needle of the gage on opening valve "A" falls to about zero and reverses in about 45 to 60 secs., climbing steadily, as do the gages of the upper siphons, until it reaches and passes the original reading, and finally stops, jerking back and forth over about 1 in. of reading each way. Thus with a difference of pools of about 8 ft. on an original reading of 7.2 ins., the final average reading was about 12 ins., or nearly twice the starting figure, the needle vibrating unsteadily between 11 and 13 ins. On closing valve "A" it settled back after some time to about 7.2 ins., corresponding with the vacuum head in the tank.

No air vents are provided for the emptying siphons, but the air is carried out with the water directly into the tail bay, about 1½ mins. elapsing from the opening of the valve till the first air appears. If one culvert gets under good headway some little time before the other, it is noticed that the stronger discharge tends to check the weaker and carries the mingled air and water into the mouth of the opposite culvert, delaying its action. When this occurs the locktenders can remedy it by admitting a small amount of air into the stronger siphon, thus retarding the flow until both culverts have gained an equally sufficient headway. Information as to the rise of the water in the siphons is obtained from the gages, and when one needle is rising much faster than the other the flow can be checked as just described. The rate of filling or emptying can be regulated as desired by admitting air into the siphons, watching the gages at the same time to see that the water does not fall below the priming level. Such regulation, however, has not been found neces-

sary, as the culverts distribute the water very evenly and quietly.

At the moment of completing the filling or emptying of the chamber there occurs the "surge" usual with locks of this size when filled by ordinary methods. The columns of water continue flowing for a second or two after the levels are equalized, causing a slight difference of head in the chamber and thereby starting open the lock gates. Thus at the end of the operation of filling, the upper gates are started open by the momentary increase of level in the chamber, and after emptying the lower gates are started open by the corresponding decrease.

The self-priming action of the siphons before referred to takes place rapidly, and as the air is drawn back from the tanks the water is drawn up through the 20-in. outlet pipes till in about 1½ mins. the gages record the original vacuum, and the reading continues to increase until it stops several inches above the original figure. To test the rise and fall of the water in the tanks during the operations a small hole was bored through the manhole cover in the west wall and a steel wire fastened to a wooden float was run through it. A second vacuum gage was then placed between the valve "B" and the west upper siphon so that the vacuum in the siphon would be indicated on closing the valve connecting with the tank. When valve "A" was opened, the head of water between the pools being between 8 and 9 ft., the float gage indicated a rapid fall of the water which gradually slackened in speed, stopping in 45 secs. after the surface had fallen 2½ ft. The first foot of fall required about 10 secs., indicating a rise in the siphon at the rate of 1 ft. in about 4 secs. When the water stopped, the needle of the vacuum gage, which had fallen to 2 ins. at the start, began to reverse, and the water in the tank and the gage needle both began to move slowly upwards. The valve "A" was then closed and a reading was taken on the second gage, and this showed by computation that the water when the reversing action began had about reached the crown of the siphon and was therefore under full discharge. In 1½ mins. from the opening of the air valve the tank was again full to the top and the needle read 7.2 ins., which was the original amount at the start. In 30 secs. more it reached a final height of 9 ins., where it stopped, jerking slightly backwards and forwards. After the flow had stopped and when the chamber was filled, the slight leakage of air in the pipes caused the gage to recede slowly to the original figure of 7.2 ins.

When the siphon reverses the action of the tank it not only refills the latter, but it also continues to draw from the lower pool through the 20-in. outlet pipe until the air-pipe is also filled, and the water runs through it into the crown of the siphon. On placing the ear to the air-pipe when the siphon is under full headway the noise of the flow of the water inside can be plainly heard.

Other tests were made to compare the time of filling the siphons by self-priming with the time noted when using the tank for the full operation. The upper pool was at El. 256.5. The filling was started by opening valve "A," closing it occasionally to obtain the height of water in the neck from the reading of the second vacuum gage. As soon as this indicated that the water had reached a tenth or two above the priming point the valve was kept closed, and the siphon then completed the filling itself, the gage indicating when the water had reached the crown. It was found that the west upper siphon with a 9-ft. head between pools, took about 25 secs. to reach the priming point and 45 to 55 secs. to become filled, and that the west lower siphon took about 40 and 60 to 65 secs. for the corresponding operations. The siphons in the east wall, owing to the long tank outlet, required from 45 to 60 secs. more for similar operations.

The tests appeared to show that if the water was lifted in the siphons to a few tenths above the one-third or priming point and connection with the tank was then shut off, they would complete filling themselves in about the same time as when the connection was left unbroken.

In case it is desired for any reason to stop the filling or emptying in mid-operation or just after starting, the valves "A" are closed and the valves "B" are opened, thus admitting free air into the necks. With a difference of pool levels of about 9 ft. the flow ceases in 35 to 60 secs. It can be started again by the usual process for the upper siphons, but if the lower ones have been broken there will probably be too much air in the necks for the tanks to take care of. In this case the upper siphons can be put in connection with the tanks and the filling of the chamber be begun again. After the water has risen sufficiently the lower siphons can be started as before by using the tanks. A quicker method is to connect the lower siphons with the upper ones when the latter have again been put under full headway, and the upper siphons will then act as a suction draft on the air in the lower ones and assist in starting them flowing again.

As each operation of filling or emptying the lock renews the vacuum in the tanks, the power is practically self-sustaining, and except for the possibility of leakage of air into the pipes, the first charging would suffice for operating the lock for an indefinite period. However, as there is a slight loss through leakage the lock-tenders usually recharge the tanks every morning, and it is found that this will supply power for the remainder of the day. In some cases a lockage has been made after an interval of 12 hours since the preceding one without having recharged the tanks. The small amount of air leaking in could probably be kept removed by attaching an automatic ejector and connecting it with the upper pool so that it would run all the time. Another method which has been tried is to close the 20-in. outlet valve at the end of the day so as to keep the tank full of water, and on opening the valve next morning the apparatus is ready for use.

FIG. 6. VIEW OF WEST UPPER SIPHON AND OPERATING VALVES.
(The valve stems to the right belong to the filling and emptying valves of the vacuum tank.)

The limits of application of this system as recommended by some of the German engineers are from about 3½ ft. to 26½ ft. (1 meter to 8 meters); others, however, have expressed their belief that the extreme lift should not be over about 20 ft. (6 meters) and that if spare basins or side ponds are used the lift should be correspondingly reduced, in order to avoid complications from the excess of air to be dealt with in the final emptying of the chamber after the water has filled the side pond. The limit of lift of course affects principally the lower siphons, since they have to carry the water to the greatest height when the chamber is almost empty, while at the upper siphons the lift is always comparatively small. The crown of a siphon with a very high lift must be kept as low as practicable, since, when the flow is approaching the lowest levels during emptying, the total lift may be too great to keep the neck full. The highest lift at present in use is 18 ft., at the lock at Lauenburg, before referred to.

The range between high and low water in the upper pool also affects the limits of application. With a low lift and a considerable range of level the vacuum tank would require a very large superficial area in order to fill the siphons when the upper pool was low, and when the water would consequently have to be lifted to a considerable height in order to start the flow. This might complicate the construction to an extent which would render preferable the use of ordinary culvert valves.

Some difficulty was at first experienced in getting the lock-tenders to understand the working of the valves, as they had been accustomed to using the "paddles" or butterfly valves in the gates of the old locks where the effect of their operation was plainly visible. One lock-tender finally adopted the method of opening first the valve which he judged to be the correct one, and if this did not appear to produce the desired effect he opened another one and continued this simple process until all the valves in the immediate neighborhood were fully open. By that time something was usually happening. If the desired result did not ensue, the valves were all closed again and another combination tried. After a short time, however, the difficulties were overcome and the operating force can now maneuver the lock without trouble.

The plans for the lock were prepared by the author during the administration of State Engineer Henry A. Van Alstyne, Mr. Henry C. Allen being then Special Deputy State Engineer in charge of the Barge Canal work. Construction was begun in 1907 under Mr. Wm. R. Hill, the succeeding Special Deputy State Engineer, Mr. Frederick Skene being State Engineer, and was completed early this year under Mr. Frank M. Williams, the present State Engineer, Mr. William B. Landreth being Special Deputy State Engineer. The Division Engineers were Mr. Henry B. Brewster and Mr. Guy Moulton, and the Resident Engineers Mr. E. Styring, and Mr. T. M. Ripley, Mr. George H. Haley being in local charge of construction. The contractors were the Gilmour-Horton-Allen Company of Hudson Falls, N. Y., with Mr. W. L. Lawton as Superintendent and Engineer.

AN EXPERIMENTAL ROAD AT ITHACA, N. Y., was constructed during 1909 and 1910 by the co-operation of the U. S. Office of Public Roads and the Sibley College of Civil Engineering at Cornell University. The general plan of these tests is much the same as that of the Ohio State Highway Commission at Columbus, Ohio, whose tests are described elsewhere in the issue of Nov. 10 at considerable length.

The Ithaca road is described in the October number of the "Cornell Civil Engineer" by Mr. Charles H. Hoyt, U. S. Superintendent of Public Road Construction. It is built in widths of 16-ft. in 15 sections as follows:

Section 1—Coal-gas tar, penetration method, 300 ft.; Section 2—Coal-gas tar, mixing method, 300 ft.; Section 3—Paving brick grouted with cement, macadam foundation, 306 ft.; Section 4—Semi-asphaltic oil, mixing method, 275 ft.; Section 5—Refined asphaltic oil, penetration method, 300 ft.; Section 6—Refined semi-asphaltic oil, penetration method, 300 ft.; Section 7—Kentucky rock asphalt, 300 ft.; Section 8—Refined water-gas tar, penetration method, 300 ft.; Section 9—Refined semi-asphaltic oil, penetration method, 300 ft.; Section 10—Open-hearth slag water-gas tar, penetration method, 100 ft.; Section 11—Open-hearth slag, 200 ft.; Section 12—Semi-asphaltic oil, mixing method, 260 ft.; Section 13—Cinder concrete, 35 ft.; Section 14—Limestone concrete asphalt paint coat, 30 ft.; Section 15—Limestone concrete, 500 ft.

The work was interrupted by the coming of winter, and in the following spring a legal question, involving the right of way, delayed the work until this last fall, when it was again resumed. It is, therefore, too early to draw any conclusions as to the respective wearing properties of the various materials. It would appear, from descriptions of the two experiments, that the Ithaca road does not have nearly as much traffic as the Columbus one.

Gravity Freight Classification Yard for the Pennsylvania R. R. at Northumberland, Pa.

By W. A. MacCART.*

At Northumberland, Pa., there is approaching completion a freight classification yard for the Pennsylvania R. R. which will be one of the largest yards on the system and will be operated by the hump or gravity method.

The entire work will cost approximately $3,000,000 and has been done under the supervision of the Construction Department of the Pennsylvania R. R., Mr. A. C. Shand, Chief Engineer, with Assistant Engineer George Nauman in immediate charge.

Location.

This yard, as will be noted by reference to the location plan (Fig. 1), is situated at the terminal of the Williamsport and Sunbury divisions, of the Pennsylvania R. R., and the Susquehanna and Shamokin divisions of the Northern Central Ry. The location was determined upon after an exhaustive examination of several sites in the vicinity, keeping in mind the cost involved in the construction of the yard and the possibilities of future changes in traffic conditions affecting the cost of operating. Northumberland was chosen for the reason that an interchange of freight between the various divisions at this point causes a reverse movement of cars, and it was desired to secure a location that would reduce the length of return haul necessitated by this interchange to a minimum.

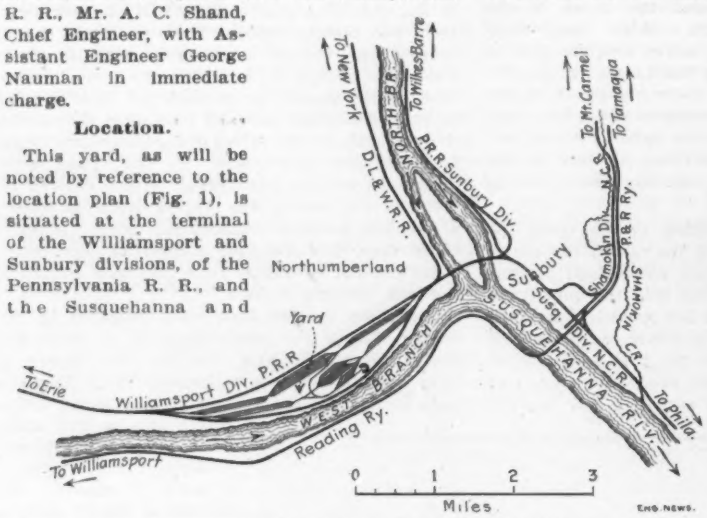


FIG. 1. MAP SHOWING LOCATION OF PENNSYLVANIA R. R. YARD AT NORTHUMBERLAND, PA.

The reverse movement results from bringing into the westbound receiving yard such cars, from the Susquehanna division destined to the Sunbury and Shamokin divisions, and vice versa, as cannot be included in solid trains moving directly between the divisions named. This will be easily understood by referring to Fig. 1.

General Description of Yard.

The length of the yard between the block towers at each end is 3.2 miles, and the maximum width (at the round house) is 1,500 ft. It required the purchase of about 480 acres of land. Fig. 3 is a plan of the yard as being built. The old main tracks were formerly located about midway between the present side limits of the yard. The ground to the south, or river side, was low, while to the north were hills from which was obtained the material for the fills. The maximum cut was about 90 ft. in depth.

The general level of the tracks at their lowest point was established at 1 ft. above the level of the maximum flood known to this vicinity.

But one stream of any magnitude crossed the yard, and that one required the construction of a 12-ft. span, concrete arch culvert about 1,550 ft. in length.

Grading.

The grading was begun in July, 1909. In order to facilitate the work, the embankment along the line of the eastbound main track was made first (wide enough for two tracks) and the main running tracks were transferred to that location in December, 1909, which permitted the contractors to proceed thereafter with no interference to their work or to train movement.

The grading involved something over 3,000,000 cu. yds. The extent of fill required is evident in the accompanying view of the roundhouse foundations, Fig. 4, which shows the masonry being built prior to the filling. The bridge shown in Fig. 2, supporting the track over the abutments at the eastbound hump was 40 ft. above the natural surface of the ground, but filling was placed here, after the bridge was built, to a depth of about 17 ft. The foundations for the coaling wharf, ash pits, power house and round house and the various wheel pits in the latter were all constructed before the fill was made. The foundations were carried down below the natural surface of the ground to good material to the depths noted below in the description of these structures.

The grading and track laying is being done by the Eyre-Shoemaker Co., of Philadelphia, who have been actively engaged on the work since July, 1909, the winter season being such that it was not necessary to entirely suspend work at any time. For the greater part of that time the contractors have had in constant use from six to eight steam shovels with the necessary equipment of locomotive and dumping cars, both narrow and standard-gage equipment being used.

Track.

The general track layout is shown in Fig. 3 and consists of receiving, classifying and departure tracks in each direction. The full lines on the plan represent the tracks now being provided and the dotted lines show proposed future extensions. The switches leading to the classification tracks will be pneumatically operated by push button machines located in the towers at the humps. As now building, the yard will contain 6.12 miles of new main tracks, 62.50 miles of thoroughfares and sidings, and 350 switches.

Attention is called to a gridiron of tracks marked "station order sifter." These tracks are located between the "local freight classification," and the "departure" tracks for the purpose of getting the cars for local freight trains in station order as they pass from the former to the latter. Provision is made for 20 classifications westbound and 30 eastbound. The track marked "for reverse cars" is for moving such eastbound cars as are received in the westbound yard to the eastbound receiving tracks in order that they may be properly classified. As the percentage of cars to be weighed is very small, scales were not placed on the humps, but located conveniently to where such cars could be sorted out and pushed over them to the receiving tracks again, ready for the final classification.

The wreck train siding is placed near the car repair tracks, a most convenient arrangement since the wrecking force is taken from the car repair men. The siding is connected with the thoroughfares in both directions to allow of prompt movement.

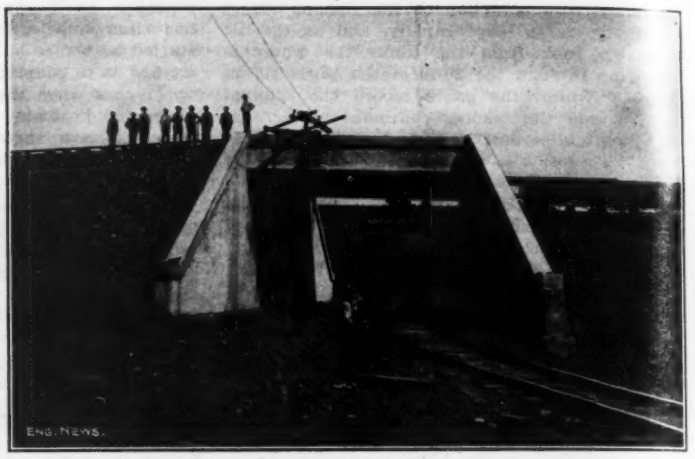


FIG. 2. BRIDGE AT EASTBOUND HUMP OVER INCOMING ENGINE TRACK.

(Yard-level fill completed; hump fill completed on one side of bridge.)

The car capacity of the various portions of the yard is as follows:

	Present construction.	Final layout.
Westbound receiving tracks..	729 cars	1,163 cars
Westbound classifica'n tracks.	859 cars	859 cars
Westbound departure tracks.	367 cars	733 cars
Eastbound receiving tracks..	487 cars	750 cars
Eastbound classifica'n tracks.	960 cars	1,170 cars
Eastbound departure tracks..	531 cars	805 cars
Total.....	3,933 cars	5,480 cars
Car repair tracks.....	132 cars	132 cars
Cripple car tracks.....	168 cars	237 cars
Engine storage.....	65 engines	95 engines
Cabin storage, westbound....	38 cabins	38 cabins
Cabin storage, eastbound....	72 cabins	72 cabins

Engine Handling Facilities.

Where classifying is done in both directions, the engine facilities are usually located between the yards, but the lay of the land and the method of handling traffic in the present yard required a departure from this plan.

The novel arrangement for reaching the ashpit and other facilities from the westbound receiving tracks is called to the reader's particular atten-

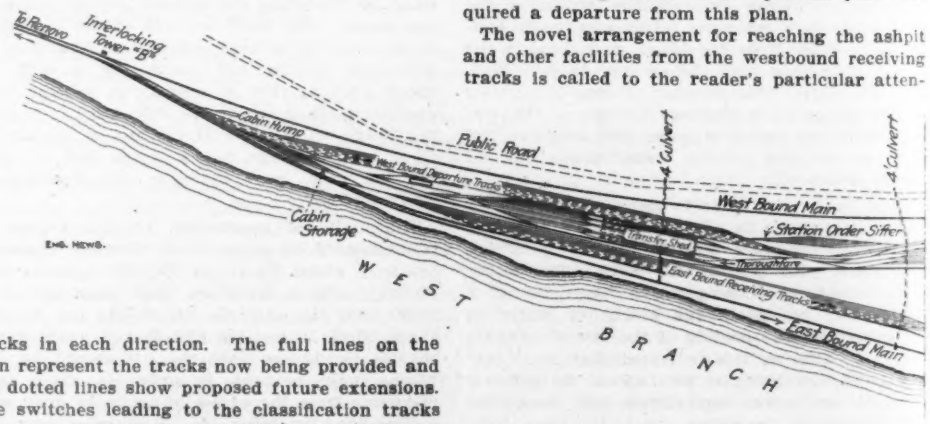


FIG. 3. TRACK PLAN OF

tion, as it dispenses with any turntable except the one in the engine house. Westbound engines are brought to the inspection pits or engine house over the loop track marked "engines in" in Fig. 3. Thus, all the arriving engines, both east and westbound, reach the storage tracks headed in one direction, viz., eastwardly. This fits in admirably with the operation, as

*Assistant to Principal Assistant Engineer, Pennsylvania R. R., Williamsport, Pa.

about two-thirds of the power is in service to the east of the yard, and the engines are pooled between the different divisions. It is only necessary, therefore, to turn the ones that are called upon to go west, and this is accomplished by using the tracks marked "engines out" (Fig. 3), parallel to the one by which the engines arriving from the east and south reached the storage tracks.

Two ashpits are coupled to each inspection pit and a Holmen coaling plant of 1,000 tons capacity, arranged to coal on either side, has been provided. It contains also the necessary sand-drying apparatus and storage bins.

Buildings.

The power plant is a brick and steel structure, 96 ft. 9 ins. × 88 ft. 7 ins., with stone and terra cotta trimmings. It is divided, practically at the midpoint of the longer dimension, into engine and boiler rooms, with an annex 32 ft. square on the boiler-room end. The main building is 38 ft. high to the cornice and has an almost flat roof. The foundation is 27 ft. in depth, but for about 12 ft. in depth it is used as a basement.

The building will contain the necessary machinery to furnish all the power and electric lighting throughout the shops and yard, the compressed air for operating the switches on the humps and testing air brakes, the pumping of water and in short all the power that is required for any purpose in the yard. The boiler room contains three 400 HP. boilers with reserve space for an additional one.

The entire yard will be lighted by electricity and equipped throughout with telephone facilities. The water supply system, which is very extensive, is so arranged that it can be quickly put under high pressure in case of fire.

The roundhouse, as planned, will consist of 36 stalls of a 52-stall house. The radius of the inner wall or columns at doorways is 107 ft. 7⅞ ins. with a depth of stall of 90 ft. 8½ ins. Two rows of columns are to be placed between the inner and outer circles to support the roof. The equipment comprises a 100-ft. turntable, a drop-table pit, an 80-in. wheel pit covering three tracks and a 62-in. and a 42-in. wheel pit, each covering two tracks.

Owing to the great depth required for foundations (some 30 ft. below track level) the form of construction to secure a minimum of cost was somewhat of a problem. Square columns, 3 ft. on a side, with a footing course 1 ft. wider on all sides and 2 ft. thick, were used under the inner circle and the intermediate rows of columns; and 2-ft. 6-in. × 4 ft. 6 in. supports were used under the outer wall columns. These foundation columns are of concrete, reinforced with vertical rods tied together at intervals.

The outer wall of the roundhouse is supported by reinforced-concrete girders, 16 ins. wide by 52 ins. in depth, placed between and suspended from the columns in the outer circle. These columns are 23 ft. 11 7/16 ins. apart between centers. The entire superstructure is being built of reinforced concrete. The roof, which is flat, is a 4½-in. slab 25 ft. above the tracks on the outer circle and 19½ ft. on the inner circle, and reinforced with ⅝-in. diameter rods spaced 6 to 8 ins. apart. The roof slab rests on concrete girders 9 ins. wide by 2 ft. in depth, reinforced with four 1-in. square twisted rods, and the girders rest in turn on concrete columns 16 ins. square with four 1-in. plain rods located near each corner. The roof covering is four ply slag, and the ventilators are of cast iron.

Adjacent to the roundhouse is a brick and steel machine shop 80 ft. 6 ins. × 123 ft. 8 ins., and a brick one-story and basement building 40 ft. × 97 ft. in plan, for oil house, locker and wash-room. Adjacent to the car repair tracks there is a planing mill 39 ft. 9½ ins. × 112 ft. 8 ins., a boiler room, wheel, pipe and smith shop 40 ft. 1¾ ins. × 129 ft. 0 ins., a storehouse, office and locker room 40 ft. 1¾ ins. × 225 ft., and a wreck gang shop 70 ft. × 209 ft. in size. All of the last mentioned buildings are of frame construction. The general yard master's office is a two-story and basement brick structure 40 ft. 8 ins. × 59 ft. 4 ins. in size.

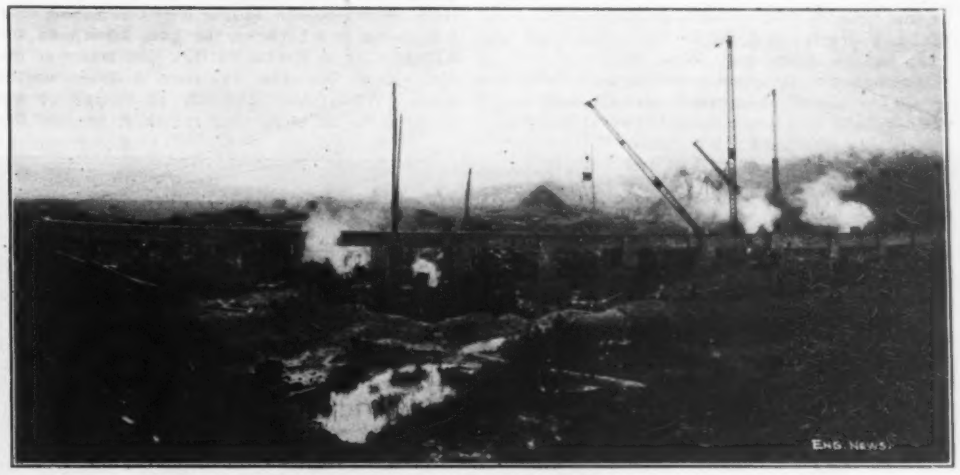


FIG. 4. ROUNDHOUSE FOUNDATIONS AT NORTHUMBERLAND CLASSIFICATION YARD.
(Photo in May, 1910; outer circle of foundation practically completed. The track level on completion will be about at the top of this masonry.)

The remaining buildings of frame construction are as follows:

Ice house	27 ft. ×	81 ft.
Hump offices	20 ft. ×	41 ft.
Push-button towers	14 ft. ×	14 ft.
Dispatcher's office, east end	20 ft. ×	63 ft.
Dispatcher's office, west end	16 ft. ×	32 ft.
Cattle pens	31 ft. ×	315 ft.

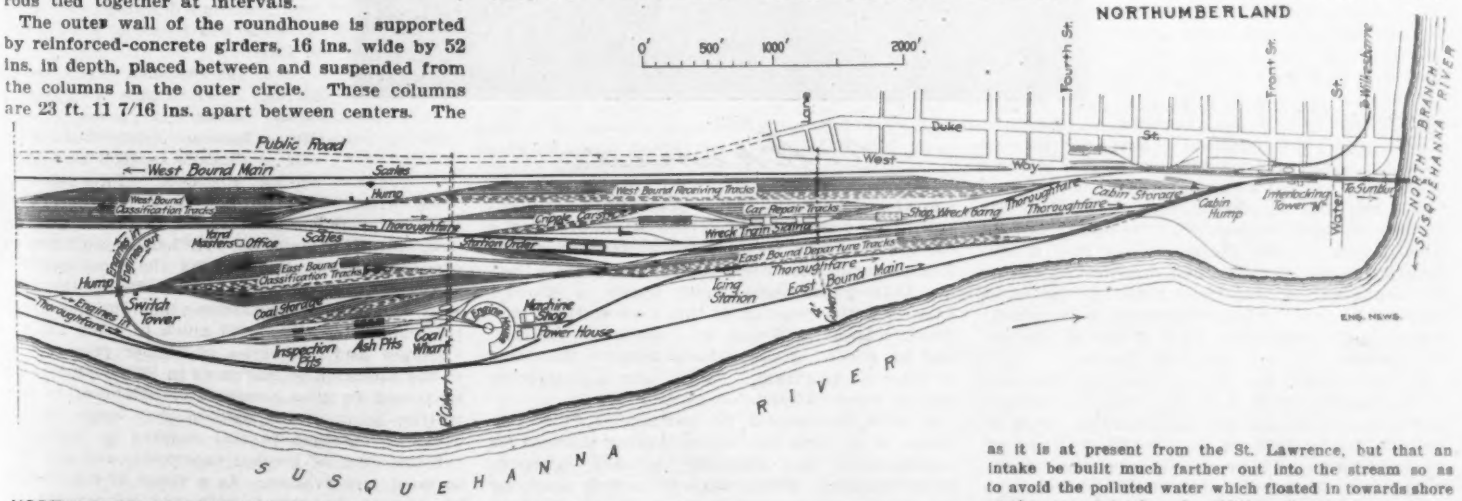
A new brick and stone passenger station 31 ft. × 75 ft. in size, with a shelter shed and platform on opposite side of tracks, connected by an underground footway, is in course of erection.

MONTREAL'S WATER SUPPLY.—A report upon an improved water-supply for the city of Montreal has recently been made by Hering & Fuller, Consulting Engineers, to the Mayor and the Commissioners of the city of Montreal. At present, Montreal is supplied with water from two sources, the municipal plant, drawing water from the St. Lawrence River about two miles above the Lachine Rapids, which is about three miles below the confluence of the St. Lawrence and Ottawa Rivers, and the Montreal Water & Power Co., drawing its water also from the St. Lawrence at a point about three miles below the foot of the Lachine Rapids. The municipal plant supplies about 347,000 people, and the private company about 200,000 people. The report made by Messrs. Hering & Fuller does not consider anything but the municipal supply.

The water of the municipal system flows through a new concrete conduit to a low-level distribution system, whence a portion is pumped to a higher reservoir for the high pressure service in the upper part of the city. There is also in progress a power canal delivering water which it is estimated will furnish about 2,500 HP., but this improvement was held up pending the investigation by the consulting engineers.

The normal death rate from typhoid fever in Montreal is somewhat lower than the general run of American cities, but during the past year there was a severe epidemic of that disease, which seems to have been a partial cause, at least, of the investigation which has recently been made. Aside from this, the water has been somewhat polluted with the soil wash of the upper rivers, and for this reason stood in need of purification.

Messrs. Hering & Fuller, in their study, considered securing a gravity supply from the Laurentian Mountains, particularly in the watershed of the River Ouareau. It was discovered, however, that the water of this river is quite highly discolored by vegetable matter, and that there is a sufficient population in the villages and near streams and lakes on its drainage area to make very doubtful at times a satisfactory hygienic quality of the water in its raw condition. It would be altogether too costly to expropriate the entire drainage area so as to eliminate possible sources of pollution, and the cost of filtration would be altogether too high to allow its being undertaken. Therefore, the engineers were forced to fall back upon the St. Lawrence River as the source of the new supply. They recommend that the water be drawn as it is at present from the St. Lawrence, but that an intake be built much farther out into the stream so as to avoid the polluted water which floated in towards shore at the present intake. In addition, they recommend that a double-filtration plant be built with a rated capacity of 50,000,000 Imp. gals. per day. It is estimated that the investment cost, exclusive of land, of such a plant will be $1,445,500, and that the annual cost of operation and maintenance, including fixed capital charges, will be $130,900. They further recommend that the power canal project be carried to completion. Although the total expense of this work is estimated somewhat above $2,000,000, it is computed that the return on the investment will make it a sound business proposition. As yet, the city authorities have taken no action upon the report.



NORTHUMBERLAND GRAVITY SORTING YARD.

Octave Chanute.

The first decade of the Twentieth Century will always be noted in the annals of engineering as the period during which "the conquest of the air" was effected, by the production of the first successful flying machines. Comparatively few, however, are aware that the present success of the flying machine is very largely due to the aid which has been rendered to the infant art by one of the Nestors of the American engineering profession, Mr. Octave Chanute, of Chicago. We believe it will be of especial interest at this time to give an account of Mr. Chanute's life and professional activities, as well as his work in connection with the aviation art..

Although Mr. Chanute is now nearly 79 years of age, he has enjoyed health and strength until very recently and while retired from active practice, he has retained his interest in engineering matters. When in Europe last summer he contracted pneumonia, and was for some time very seriously ill, so much so that his recovery was hardly expected. He did recover, however, and was able to return to this country in October; but he is still in a very weak condition.

In the following review of Mr. Chanute's long and distinguished career, the earlier part is taken largely from a biographical sketch published in Engineering News, May 23, 1891, in which year Mr. Chanute held the Presidency of the American Society of Civil Engineers.

Mr. Chanute was born in Paris, France, Feb. 18, 1832, and was brought to the United States when only six years old. He received his education chiefly in New York City, and began work in civil engineering in 1849, on the construction of the Hudson River Ry., under the famous John B. Jervis, Chief Engineer. He was gradually promoted as the work progressed over the several divisions of the road, and when he left the service of that company, in 1853, although only 21 years old, he was Division Engineer at Albany, in charge of the completion of terminal facilities and maintenance-of-way between Hudson and Albany.

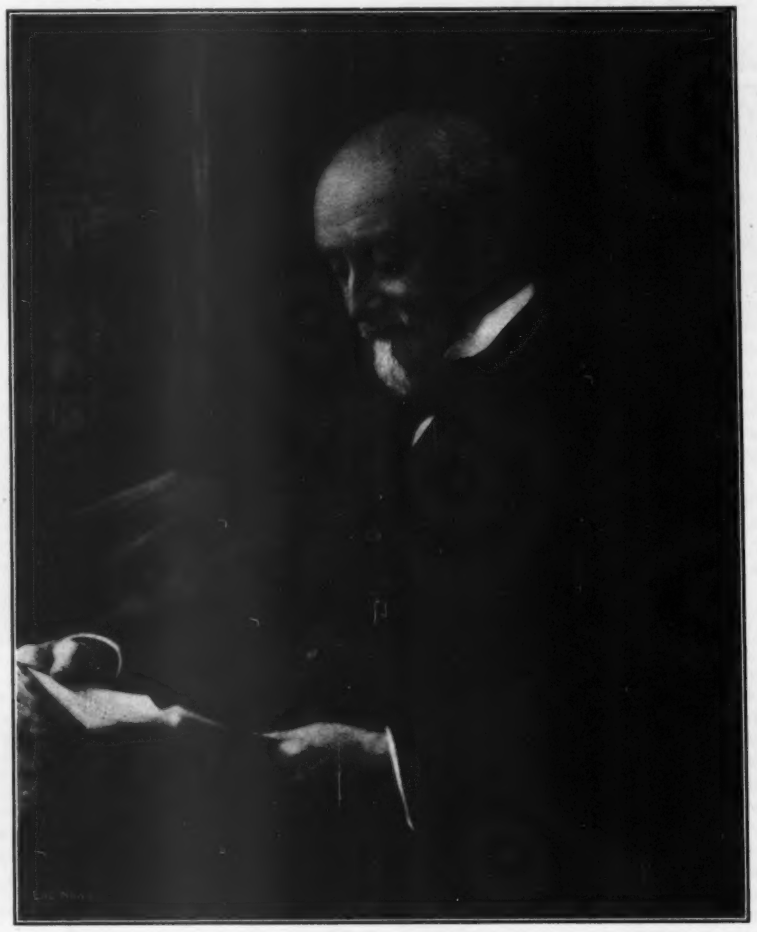
He then went to Illinois with H. A. Gardner, previously Chief Engineer of the Hudson River Ry., and was there engaged in building what is now a part of the Chicago & Alton Ry., between Joliet and Bloomington. Mr. Chanute remained upon this work until 1854, when he was made Chief Engineer of the eastern portion of the Toledo, Peoria & Warsaw Ry. He built this road from Peoria to the Indiana state line, a distance of about 112 miles, and remained in charge of maintenance-of-way until 1861. In the latter year he became Division Engineer, with similar duties, on the Pittsburg, Fort Wayne & Chicago Ry. between Chicago and Fort Wayne.

In 1862, he was for six months Chief Engineer of Maintenance-of-Way of the Western Division of the Ohio & Mississippi Ry., from St. Louis to Vincennes. In 1863 he became Chief Engineer of Maintenance-of-Way and Construction of the reorganized Chicago & Alton Ry. and remained upon that line until 1867.

During this period he was invited to submit a design for the proposed Union Stock Yards of Chicago. His plan was selected in competition with a number of others and he built these yards as Chief Engineer. He was also awarded a premium for a competitive design for a bridge across the Missouri River at St. Charles, Mo.

In 1867, Mr. Chanute went to Kansas City, Mo., as Chief Engineer of the bridge across the Missouri River at that point. This was the pioneer bridge across that river, and as the river pilots and riparian dwellers had given the stream a bad reputation, the successful completion of this bridge across it in 1868 attracted great attention.

Meanwhile the building of railways had begun in Kansas, and while yet occupied in the completion of the bridge, Mr. Chanute was placed in charge as Chief Engineer, first of the construction of the Kansas City, Fort Scott & Gulf Ry., from Kansas City to the north line of the Indian Territory, 160 miles; next of a parallel line in the same interest, then known as the Leavenworth, Lawrence & Galveston Ry., from Lawrence, Kan., to the Indian Territory; next of a connecting line between the two, known as the Kansas City & Santa Fe Ry., and lastly of the Atchison & Nebraska Ry., from Atchison northward. While simultaneously in charge of the construction of these four railways, he also designed and built the Union Stock Yards at Kansas City; and in 1871, as the work drew to a close, he became General Superintendent of the Leavenworth, Lawrence & Galveston Ry. During that period three small towns in Kansas, located at the junction of this road and the Missouri, Kansas & Texas Ry., were consolidated, and by a vote of the citizens adopted the name of Chanute (Kansas). This is now a prosperous city of some 15,000 inhabitants.



O. Chanute

In 1873 he accepted the position of Chief Engineer of the Erie Ry., which, having changed its management, was planning to make extensive improvements. These were to include doubling the tracks and narrowing the gage (to standard gage), building an extension to Chicago and another to Boston (involving the Poughkeepsie Bridge, since built in another interest) and building sundry branches and improving the property generally at an estimated outlay of some $50,000,000, which it was expected to obtain in England.

The panic of 1873 and the subsequent financial depression prevented the full carrying out of this program. Mr. Chanute, however, remained upon the Erie Ry. for 10 years, during which time much of the line was double-tracked, given improved grades, the gage reduced to the standard by laying down a third rail, and the facilities of the line largely improved. The Great Kinzua Viaduct, over 300 ft. high, was built under his direction during this period.

In 1875, he was made Assistant General Superintendent of the Erie, and in 1876 was placed temporarily in charge of the motive power and rolling stock, in addition to his duties as Chief Engineer. This gave him an opportunity of improving the locomotives as well as the grades, so that the standard through freight train, which averaged 18 cars when he first became connected with the line, had grown to 35 cars when he severed his connection with the road in 1884.

In that year he removed from New York to Kansas City in order to look after his personal interests, and to open an office as a Consulting Engineer. In this latter capacity he took charge of the construction of the iron bridges during the building of the Chicago, Burlington & Northwestern Ry., between Chicago and St. Paul in 1885, and of those on the extension of the Atchison, Topeka & Santa Fe Ry., from Kansas City to Chicago in 1887 and 1888.

The extension of the latter road involved the construction of the Missouri River bridge at Sibley, Mo., and the Mississippi River bridge at Ft. Madison, Ia. These bridges, as well as the Kansas City bridge mentioned above, are important structures and they were especially notable at the time they were built. The location and general plan of the Sibley Bridge were determined by Mr. Chanute, and he was Consulting Engineer during the execution of the work. This bridge was about 2,000 ft. long and had three channel spans of 400 ft.; in addition there were nearly 2,000 ft. of iron viaduct approach. The bridge was commenced in March, 1887, and completed in 1888. The Fort Madison Bridge has four spans of 237½ ft., one of 275 ft., two of 150 ft., and a swing span of 400 ft. Pneumatic caissons were used for some of the pier foundations. The bridge was commenced in March, 1887, and completed on Dec. 7 of that year. It was described and illustrated in our issues of June 2 and 9, 1888.

After the extended experience in railway and bridge engineering work which is noted above, Mr. Chanute established himself at Chicago in 1889 as a Consulting Engineer. Two lines of work with which he has been identified conspicuously are the preservation of timber and the development of aviation. He had been Chairman of a committee appointed by the American Society of Civil Engineers to investigate the subject of timber preservation, and the report of this committee (1885) did much to bring the advantages and economies of timber preservation to the attention of engineers in this country. He continued to give considerable attention to this matter, being of the opinion that large savings could be obtained in this country by following out the lines of foreign experience and practice in wood preservation. As a result of his studies he became impressed with the advantages of zinc-chloride as a preservative, especially in view of the then existing conditions of high price and limited supply of creosote oil suitable for such work. In 1885, he organized the Chicago Tie Preserving Co., which has treated large quantities of railway ties, mainly by the Burnetising or plain zinc process, but also by the zinc-tannin, zinc-creosote and other auxiliary processes. At the present time the business is carried on under the firm name of O. Chanute & Co. In addition

to its commercial work, the company carried on much experimental and investigation work, and Mr. Chanute has been recognized universally as a leading expert on the subject.

The science of aviation first attracted Mr. Chanute about 1874, at which time few engineers gave any consideration to the subject. He found, however, that this "side issue" interfered with his regular professional work, and he laid it aside until 1888, when he was in a position to give more time to it. He studied the question at first from a theoretical standpoint, and then undertook a number of gliding experiments with aeroplanes, which type of air-ship appeared to him to be the most promising for practical development. The aeroplanes were designed by him and are known as the Chanute type. During the experiments of the Wright Brothers from 1901 to 1905 he made at their request numerous calculations for them and supplied them with both information and advice. He published a book on "Progress in Flying Machines" in 1894. In 1897 he presented to the Western Society of Engineers (Chicago) a paper on "Gliding Experiments" and in October, 1909 a paper on "Recent Progress in Aviation." In this paper he made the following remark with reference to his experiments recorded in the paper of 1897:

> That publication contained the statement that it was thought these experiments were promising, and I gave an invitation to other experimenters to improve upon our practice. That invitation remained unaccepted until March, 1900, when Wilbur Wright wrote to me, making inquiries as to the construction of the machine, materials to be used, the best place to experiment, etc. He said that he had notions of his own that he wanted to try, and knew of no better way of spending his vacation. All that information was gladly furnished.

In introducing Mr. Chanute at this latter meeting, the President of the Society (Mr. Andrews Allen) referred to his earlier paper of 1897, and remarked that the opportunity came to few men to appear before a society 12 years after their predictions had been made and be able to point to the fulfillment of these predictions.

In addition to his writings noted above, Mr. Chanute has contributed a number of papers and discussions to the "Transactions" of the American Society of Civil Engineers. Among these may be mentioned the following papers: "The Sibley Bridge," "The Weight of Rails and the Breaking of Iron Rails," "The Elements of Cost of Railway Traffic," "Repairs of Masonry," "Uniformity in Railway Rolling Stock," and "The Preservation of Railway Ties in Europe." He was also an active member of several important committees of the Society, including those on Railway Signals (1875); Rapid Transit and Terminal Freight Facilities (1875); The Form, Weight, Manufacture and Life of Rails (1874-1876); and Preservation of Timber (1885). He was chairman of the committees on terminal facilities and timber preservation. The rail committee's work laid the foundation for the further investigation which resulted in the recommendation of the Am. Soc. C. E. rail sections in 1893. The timber preservation committee's report was a very thorough presentment of the subject at a time when but little was known about the matter in this country. It should be noted that the paper on "The Sibley Bridge" (composed of three separate sections by Mr. Chanute, Mr. John F. Wallace and Mr. W. H. Breithaupt) was awarded the Rowland Prize of the Society in 1890. Mr. Chanute has made contributions also to the Proceedings of other societies.

He became a member of the American Society of Civil Engineers in 1868. He was Vice-President in 1880 (preparing the annual presidential address owing to the absence of the president in Europe), and was elected President in 1891. He was President of the Western Society of Engineers in 1901, and was elected an Honorary Member of this Society in 1909, having been then a member since 1869. He is an Honorary Member also of the Institution of Civil Engineers of Great Britain, of the Society of Civil Engineers (France), and of the Chilean Society of Engineers. He is a member of the Canadian Society of Civil Engineers, the American Institute of Mining Engineers, and the American Railway Engineering and Maintenance of Way Association. As a prominent aeronautical engineer he is a Fellow of the American Aeronautical Society, an Honorary Member of the Aero Clubs of America and France, and President of the Illinois Aero Club. During the summer of 1910 he was elected an Honorary Member of the Aeronautical Society of Great Britain, and that society awarded to him a gold medal in recognition of his distinguished services in promoting the art of aviation.

At the time of the Columbian Exhibition, held in Chicago in 1893, he was chairman of the Executive Committee of engineering societies which had charge of the arrangements for the International Engineering Congress held in connection with the exhibition. This was an occasion of great importance, and Mr. Chanute was among the most active and energetic of those who planned it and carried it to a successful issue. In 1905, the University of Illinois conferred upon him the degree of Doctor of Engineering.

He was married in 1857 to Miss Annie James, of Peoria, Ill., who died in 1902. He has one son and three daughters living.

Land Drainage in Illinois.

The land drainage work of Illinois (and of several of the central states) has for several years afforded a special field of work for engineers and contractors. More work of this kind is done as the demand for and value of land increases. The information given below as to the work in Illinois is condensed from an article prepared by Mr. J. A. Harman, M. Am. Soc. C. E., of Peoria, Ill., for the "Herald-Transcript" of that city.

In the valley of the Illinois River, extending from La Salle to the Mississippi, 230 miles, nearly 150,000 acres of land have been reclaimed by drainage. The several drainage and levee districts in this valley are given in the accompanying table. The cost of maintaining the levees and operating the pumping plants ranges from 30 to 60 cts. per acre per year, and the law limits the assessment for these purposes to the latter amount.

There are in Illinois 2,000,000 acres of fine bottom lands which could be reclaimed and made highly productive by intelligent drainage. This land is the very choicest to be found, consisting of alluvial deposits of the overflowing streams (the washings from the best soil of the upper lands). In 1879 the first drainage laws were passed by the legislature, defining the rights of landowners with respect to the subject and authorizing the incorporation of drainage districts. In 1885 these laws underwent a general revision.

The problem of the Illinois farmers of 50 years ago was virtually the same as that which confronts the bottom land farmer today. The lands under cultivation were not overflowed, but practically one-third of the state was swampy and too wet for production. Drainage in a crude way reclaimed much of the present highly productive land, but the progress of the general movement was slow and made but little headway so far as it pertained to the submerged bottom country.

About 1893, drainage of farm lands began on a larger scale in the northern two-thirds of the state and practically all of the uplands not subject to overflow were more or less thoroughly drained.

The total area of lands already reclaimed, however, is small as compared with the possibilities opened up by modern engineering methods and machinery. About 50% of the Illinois River valley lands have been drained and 75% of the available lands along the Missouri valley in Illinois.

Probably the greatest awakening in the matter of wholesale drainage has been evinced in the project to reclaim the immense valley of the Kaskaskia river in southern Illinois, a strip of overflowed bottom lands containing upward of 300,000 acres. The U. S. Geological Survey and the Illinois State Geological Survey cooperated in gathering topographical data and recently turned over their report to the Internal Improvement Commission of Illinois, of which Mr. Isham Randolph is president. This commission has had surveys made by the Harman Engineering Co. of Peoria, with a view to ascertaining the most practical division of the territory into drainage districts and the best methods of completing the reclamation.

The cost of draining overflowed lands usually ranges from $15 to $40 per acre; a few of the smaller tracts cost more, and the average may be safely placed at $25. As 75% of the lands have absolutely no producing value in their natural state, and the selling value before the prospects of reclamation were opened up was but $1 to $5 per acre, it will be seen that the cost of drainage represents practically the total price paid by the owner for farm land which becomes salable and productive. The minimum price of these lands which formerly were unsalable except to hunting and fishing clubs at $1 to $5 per acre, now have a minimum value of $20. The reclaimed and improved lands have a ready market value ranging from $60 to $150 per acre, the drainage taxes on the tracts to be paid in addition by the purchaser.

Ordinarily about five years elapse from the time a drainage district is organized until the land is brought under cultivation. The work of digging ditches, building levees and constructing pumping plants requires practically two years. The remaining task of individual draining by tile and open ditches, eliminating swamp grass, pulling stumps, building roads and erecting fences, occupies about three years more.

The actual work of construction begins with the plans of the engineer, who maps out the ditches and levees and determines the necessary pump capacity. The ditches are from 20 to 8 ft. wide. The minimum depth is usually 6 ft., in order to provide good outlets for tile drains from the lowest places in the area drained. The levees are from 10 to 15 ft. high, and vary in width from 3 ft. at the top to 70 ft. at the bottom.

Under the drainage laws of Illinois the project of establishing a drainage district may be begun on petition of one-third of the land owners in the proposed district, representing not less than half the land, or half the owners representing not less than one-third the land. This petition is presented to the court of the county in which the majority of the land lies, and the court sets a date for a hearing. All land owners may be heard on the question and if the court is satisfied that a district should be established it appoints three commissioners to investigate the lands, make surveys and report as to the feasibility of the project. Included in this report, if favorable, are plans, profiles, estimates of cost and recommendations as to procedure. Notice is then given for a final hearing and if the court decides in favor of the organization the drainage district is chartered as a municipal corporation with authority to procure right of way, condemn lands under the power of eminent domain and assess taxes for the construction and maintenance of ditches, levees and pumping stations. The tax for construction purposes may not exceed the amount of benefits to the land, and the tax for maintenance is limited to 60 cts. per acre.

After the cost is determined, the assessment is entered and collected the same as regular taxes, or through the authorized treasurer of the district. The usual proceeding is to issue bonds, the first payable five years after issue and the last 25 years after issue, bearing interest at 6%. These bonds have ready sale, as there have been but two defaults on the part of districts, and these were in the early history of drainage.

DRAINAGE DISTRICTS IN THE ILLINOIS RIVER VALLEY.

	District and county.	Area, acres.	Approx. cost	Approx. pumping capacity per hour, gals.	
1.	Hennepin (Putnam)	2,500	.....	.....	Under construction.
2.	Partridge (Woodford)	3,000	$100,000	1,000,000	Nearly completed.
3.	East Peoria (Tazewell)	750	55,000	800,000	Not begun.
4.	Pekin and Le Marsh (Peoria)	2,800	100,000	1,000,000	Completed.*
5.	Spring Lake (Tazewell)	14,000	300,000	9,000,000	Nearing completion.
6.	Banner (Peoria and Fulton)	5,000	150,000	3,000,000	Not begun.
7	Lacey (Fulton)	5,700	.....	(2)2,000,000	Completed.*
8.	Coal Creek (Schuyler)	7,000	.....	2,000,000	Completed, 1898.*
9.	Crane Creek (Schuyler)	5,000	135,000	.....	Nearly completed.
10.	Meredosia (Morgan)	5,000	101,000	1,000,000	Completed, 1904.*
11.	Magee Creek (Brown)	12,000	.....	3,000,000	Completed, 1908.
12.	Scott (Scott)	12,000	168,000	.....	Not begun.
13.	Big Swan (Scott)	12,000	200,000	3,000,000	Completed, 1908.
14.	Hillview (Scott and Greene)	11,000	275,000	2,500,000	Completed, 1909.
15.	Hartwell (Greene)	12,000	.....	(Note)	Completed, 1907.*
16.	Keach (Greene)	10,000	.....	.....	Completed, 1908.*
17.	Eldred (Greene)	9,000	250,000	3,000,000	Under construction.
18.	Nutwood (Greene and Jersey)	11,000	279,000	6,000,000	Completed, 1910.

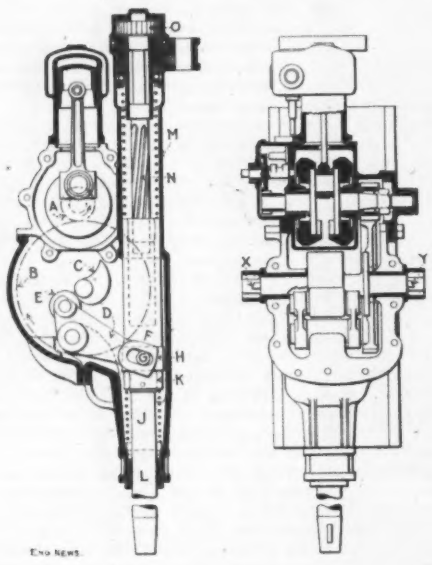
*Notes.—(4). Levee completed, 1889; first pump installed, 1904; levee rebuilt and new pump installed, 1907.
(7). Completed about 1893; first pumping plant, 1900; second pumping plant, 1906.
(8). Ditches rebuilt, 1909.
(10). Pumping capacity now being doubled.
(15). Two pumping plants serve portions of the district. The levees were rebuilt after being broken by the high waters of 1902 and 1903.
(16). Pumping plant recently installed.

An English Gasoline Rock Drill.

Rock drills operated by gasoline have been introduced to a limited extent in this country, and one drill of this type was illustrated in our issue of Nov. 26, 1908. In the "Engineer" (London) of Sept. 30, is a description of a later drill of this sort, made by the Warsop Petrol Rock Drill Syndicate, of Chorley (Lancashire), England. The machine is shown in the accompanying cut, and the description is as follows:

So far as the construction of the drill is concerned it differs but little from the ordinary article operated by steam or compressed air, but the utilization of a gasoline engine is a feature both of interest and importance. The employment of this type of engine naturally has the effect of making the drill extremely portable. Moreover, the machine is always ready for immediate use, and can be started in a few seconds. The method of gearing the engine to the drill can readily be followed by reference to the drawing.

On the crank shaft there is a pinion (A) which meshes with the spur wheel (B), the reduction ratio being 4 to 1. The cam (C), which revolves with the wheel (B), and which is formed in one piece with the cam shaft, imparts a rocking motion to the bell crank lever (D), a roller being provided at (E). The end (F) of the bell crank lever engages with the stud (G) attached to the collar (H), which is capable of turning on the drill spindle



An English Gasoline Rock Drill.

(J), and is held in place thereon by the sleeve (K), which is fixed to the spindle. At its lower end the drill spindle (J) reciprocates in the socket (L), and in the upper end in a chamber forming part of the casing. This chamber encloses the spring (M), which forces down the spindle after compression. The rotation of the spindle is effected by means of the fluted bar (N) and ratchet and pawl at (O) in the usual and well-known manner.

The mechanism enclosed in the casing, together with the engine, slides in grooves formed on each side of the carriage or cradle, for fixing to a tripod stand or other support. The drill and its driving mechanism are fed forward by means of a screw. The engine can be started at either end of the crank shaft by the aid of a handle inserted either at (X) or (Y). The general appearance of one of these rock drills mounted on a tripod is very much the same as that of any other mechanically-operated rock drill.

The cylinder of the engine is water-jacketed. The gasoline tank, ignition apparatus, carburetter, etc., are contained in a single case, which can either be placed on the ground or fixed at the back of the engine. The tank, which is contained in the upper part of the case, holds about one gallon of gasoline, this supply being sufficient to operate the drill for about eight hours.

For shaft sinking the drill is mounted on a stretcher or cross bar extending across the shaft. The jumpers can be changed by giving one turn to the fixing nut, and the drill may be tilted on one side sufficiently to allow long jumpers to be inserted. For drilling plug-and-feather holes the machine is mounted on a bar of special form, with provision for adjustment, so that holes may be drilled at any angle. It is evident that, in addition to the other advantages, the initial outlay for a machine of this description must be appreciably lower than when a boiler or compressed air plant is used.

Notes on Construction Methods Used on the Lansing & Northeastern Ry., Michigan.

The construction of electric interurban railways is carried on in generally much the same way as that of steam railways, but differs in a number of respects as to the equipment used and the details of the work. We give herewith a description of the construction and tracklaying of the Lansing & Northeastern Ry., information as to this work having been furnished to us by Mr. W. J. Sullivan, the Chief Engineer, of Morrice, Mich.

The Lansing & Northeastern Ry. is an electric railway being constructed from Haslett to Owosso, Mich., a distance of 24½ miles. It is of the third-rail type of construction, except that trolley construction is used in passing through cities and villages along the line. The Michigan United Railways own and operate an electric railway from Lansing to Pine Lake, a summer resort 8½ miles distant from the city and near to Haslett. This resort affords plenty of business during the summer months, but after the expiration of the season, car service is infrequent; hence the desire to reach out into new territory.

The grading averages about 10,000 cu. yds. of earthwork per mile, although on some miles these figures were greatly exceeded on account of the location of sink-holes which abound in the lake region. The railway is being built upon private right-of-way. It is not desired to exceed a 1% grade as a maximum, although conditions have necessitated the use of 1.75% grades upon short stretches of the line. Vertical curves are used at summits and sags.

The curves do not exceed 3% on any track outside of city limits. The maximum curves are 10%, 12% and 24%, all being located in cities or villages. All curves above 2% are spiralled and are elevated as follows: 3 ins. for 1° curves, 4 ins. for 2°, 5 ins. for 3°, and 5½ ins. for 4°. In no case does the elevation exceed 7 ins. for any degree of curvature. It has been found that the electric road needs a greater elevation than is usually given on steam railways, on account of the high speed of the electric cars. This condition is due probably to the fact that the center of gravity of the cars is much lower than on locomotives, thereby bringing a greater strain upon the track.

The track construction is designed to ensure safe high-speed track which can be operated at the minimum cost for maintenance. The existing track (trolley line) is laid with 67-lb. rails. The new work is being laid with 70-lb. track rails, spliced with continuous joints. The third rail is a 60-lb. low-carbon steel rail of the following analysis: carbon, not over 0.14%; phosphorus, 0.11%; manganese, 0.40%, sulphur, 0.08%; silicon, 0.05%. The full carrying capacity of this rail section is equivalent to 1,091,000 c. m. of copper. At farm and road crossings, where the third rail is interrupted, the current is carried across by means of overhead jumper cable construction. The track rails are bonded with all-wire rail bonds, having compressed terminals which are attached to the outside of the head of the rail.

There are 16 ties for each 33-ft. rail, or 2,560 ties per mile. Each sixth tie is 9 ft. in length to provide support for the third-rail insulator blocks. Cedar ties are used for all work outside of city work; and either chestnut or oak ties for city work.

The grading is done by contract, work being let to the lowest responsible bidder. The balance of the work (such as tracklaying, ballasting, trolley and telephone construction, and building of fences and all other incidental work) is done by a construction company (the Northern Construction Co.) for the railway.

The tracklaying has all been done by hand labor, as the work is not in such shape or of such extent as to warrant the use of a tracklaying machine. The material yard is located at about the middle of the line, and material is delivered at any point along the line by the use of engines and flat-cars. Enough rails are loaded on the cars to keep the force busy for one day, and at night sufficient material is again loaded to carry on the work for the succeeding day. The ties are distributed by teams, piles of ten ties each being placed at intervals of 24 ft. There is one 9-ft. tie in each pile, and another is dropped midway between each pair of piles. A gang of six men with a foreman places the ties on the roadbed, lining and spacing them ready for the rails. As the line parallels a steam railway for about half the distance, ties can be delivered at railway stations, so that the team haul is not prohibitive.

In laying track, a flat-car equipped with irons and rollers is used, this car being attached to the front of the train carrying the rails. This car also carries rail splices, bolts and spikes needed. Each rail is run forward along the rollers by manual labor to the first car, where the rail gang is in readiness to receive it and place it in position. When this is done and the forward end is laid to gage and the heel joints are half bolted, the rail joint is attached to the track end, the second rail being laid in the same manner. The rails are then quarter spiked, and the train moves ahead. The rails are laid with broken joints.

The tracklaying gang is made up as follows:

1 foreman, 1 assistant foreman, 6 men unloading rails from cars, 12 men with tongs, to place the rails, 2 splice men, 4 spikers, 2 nippers, 1 man to line ties, and 1 man to distribute spikes.

The back-bolting (behind the train) is done at the same time that the joints are bonded, as it is the practice to bond the rails as soon as they are laid and before the track is ballasted. This back-bolting requires two extra men for the bonding gang, and they are in charge of the foreman of that gang.

Ballast is secured from a gravel pit at a point near the middle of the line, and is distributed from center-dump cars. The ballast is placed under the track by jacking it up into position, no attempt being made to distribute ballast ahead of the track. The engines can handle a train of from eight to ten center-dump cars. After unloading these cars, the spread is made by a center plow which is attached to the rear or plow car of the train. In ballasting there are from 40 to 50 men in a gang, one man being used to prepare the holes for the reception of the jacks; two jacks and four jackmen give good results with a force of this size.

The pole line for both trolley and telephone construction is erected after the track is laid, thereby permitting all material to be distributed by the work trains. The transmission line (40,000 volts) is strung upon a line of tower construction, but as electric power is furnished by a separate corporation the railway has nothing to do with this work. The trolley line is installed upon wooden poles with bracket construction, excepting in cities, where iron poles and span-wire construction are used.

Vitrified pipe is used for waterway openings up to 18 ins. diameter. Reinforced-concrete pipe is used for openings from 30 ins. to 48 ins. diameter. The larger waterways have reinforced-concrete culverts designed for Cooper's E-50 loading. Such bridges as there are on this line are pile bridges or trestles.

As to the organization, the construction company has a superintendent of construction, Mr. N. B. Atwood, who cares for track work, ballasting, line work and all other work incidental to the construction of the railway above subgrade. He also has charge of the construction and placing of all the openings for waterways. He is assisted by the track, line and bridge foremen and the material clerk, together with the office force required to handle the pay-rolls of his department. The Engineering Department of the railway company is in charge of Mr. W. J. Sullivan, as Chief Engineer, assisted by two field assistants and by a draftsman who takes care of the design of structures and sub-stations. The Engineering Department has charge of the designing and building of all structures, the grading, the preparation of the preliminary monthly estimates, setting of ballast stakes and track centers, and all the work incidental to such a department.

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If the officials of water companies and city water-works felt undue elation over the Special Master's report in the famous Peoria electrolysis suit, which we published in August, 1909, the recent decision of Judge Sanborne, which does not support the Master's report, will not be especially gratifying. A careful study of both documents, however, will show, as might have been expected, that the Court takes a very conservative view of the whole electrolysis situation. The Judge's opinion does not seem unduly favorable either to the railroads or to the water companies, for it places on the one the responsibility for injury, arising from negligence, and on the other the requirement of active cooperation.

The Special Master's findings may be condensed to four points: (1) The slightest difference in potential between a track system and a pipe line indicates the ultimate destruction of the pipe; (2) the double overhead trolley is the only sure remedy for electrolysis of underground pipe lines; (3) the railway companies should be enjoined from operating without completely preventing electrolysis; and (4) damages for injury may be recovered, even in event that the railway company has attempted to prevent or limit the escape of current.

The first point of the Special Master in the Peoria case obviously would not be stated so positively by an engineer. It is now agreed by the most competent electrical engineers that considerable potentials may exist for years as in this case, without any real damage by electrolysis, that other and hidden local conditions may govern, and that it is necessary to ascertain if current is leaving the pipes and in approximately what quantity. Out of a mass of conflicting "expert" testimony, the court has recognized this.

The right to prescribe the system which a railway must install, provided the franchise conditions are already fulfilled, does not lie with the courts, according to Judge Sanborne and the authorities he quotes. That right is a legislative function vested in legislatures, municipal councils or public service corporations.

What is now binding on this particular electric railway, and naturally on all others which wish to avoid trouble, seems then to be merely the exercising of every precaution and the employment, in a bona fide manner, of every reasonable means to so perfect their return circuits as to substantially reduce if not absolutely prevent current leakage. Injunctions to that end may issue on condition that the complaining pipe owner shall cooperate to prevent the escape of current to and from his pipes.

For instance take the hypothetical case of a railway track making a long detour where a gas or water-pipe line cut across lots and formed a better path than the track and return feeders, so that current went to and from the pipe causing deterioration. We should presume, following this decision, that after all reasonable perfection of bonding and auxiliary conductors, the owner of the pipe line would be obliged to assist the company by inserting insulating joints at proper points in his pipe line, or by permitting the connection of different points of his pipe line to an auxiliary conductor parallel with it, as might be deemed best.

This decision, if no arguments are brought up to vitiate it and a decree is finally issued in accordance with it, seems to lead to a better understanding of the relative status of two different public utilities serving the people in the same territory. It seems to indicate that the courts will not demand an absolute freedom from operating injury to one system which will unreasonably increase the expense and hazard of operating the other. In other words, the damage burden caused by the juxtaposition of the two plants may be irrepressible and is then to be divided. It would seem probable that the greater part of the unavoidable burden would bear on the newer concern, whether railway or pipe system, but that every reasonable measure of cooperation to lessen the total burden would be still incumbent on the utility first in the field.

The petition of the railway companies for permission to advance freight rates, now before the Interstate Commerce Commission, rests chiefly on the ground that the horizontal advance in wages, made early in 1910, has so reduced net revenues that an advance in rates is essential to railway prosperity. It is of interest, therefore, to see what official statistics show as to railway net earnings at present compared with those of a year ago.

A Bulletin has just been issued by the Statistical Bureau of the Interstate Commerce Commission showing the earnings and expenses of the steam railways of the United States for July, 1909, and July, 1910. The important totals in these statistics are as follows:

	July, 1909.	July, 1910.	Increase or decrease.
Total operating revenue	$217,803,000	$230,615,000	I. $12,812,000
Total operating expenses	140,160,000	157,458,000	I. 17,298,000
Total net revenue*	78,139,000	73,477,000	D. 4,662,000

*The "net revenue" is a little greater than the difference between operating expenses and earnings as there are some earnings outside of railway operations.

It is evident from the above statistics that railway operating expenses have increased faster than the earnings. The railways carried a heavy traffic in July last. They earned in round numbers 13 million dollars more than in July, 1909; and while part of this increase in earning is due to the fact that about 5,000 miles more of line were in operation this year than last, the average earnings per mile of line were increased, proving that traffic was actually heavier. Operating expenses, however, increased in still greater ratio. Seventeen and a quarter million dollars more was paid out to run the railways in July, 1910, than in July, 1909, and there was over four and one-half million dollars less to pay taxes, interest and sinking fund charges on bonded debt, to lay out on permanent improvements and to pay dividends to stockholders. This is not quite the whole story, either, for the Commission's statistics show that one-twelfth the annual taxes, for 1910 were nearly a million dollars more in 1910 than in 1909. This extra burden of taxes makes the net revenue available for interest charges, dividends and permanent improvements for July, 1910, less by five and one-half million dollars than in July, 1909. If this falling off in net revenues for July continues for a year, it would reduce the net revenues above expenses and taxes by 66 million dollars.

Of course this is the story of only a single month, but it seems to us a stronger argument by far for an increase in rates than any that we have seen before.

A New Proposal to Secure Power on a Large Scale from Intermittent Natural Sources.

In Engineering News last year (May 13, 1909, pp. 509, 511 and 522) we recorded the work of two American engineers, who have independently been seeking to utilize the energy of solar radiation for the development of commercial power. The striking thing about both of the rather similar methods noted was the employment of a small temperature drop in the working media—a radical departure from the methods adopted by Ericsson in his sun-power engine, and by later imitators.

In September, in a paper before the Engineering Section of the British Association for the Advancement of Science, Prof. R. A. Fessenden, of Washington, D. C., outlined a plan for developing power from two natural sources—the sun and the wind. This paper aroused no little interest, especially abroad. But so far as solar power was concerned, his scheme involved the same idea of working with a small temperature drop.

He also proposed to combine wind and sun-power apparatus with the idea that such a plant could furnish a fairly constant power output with only moderate storage. Windmills would pump water from a subterranean reservoir, 1,000 ft. below ground, to a surface pond and the return of the water to the lower reservoir would be used for the generation of power by some sort of a hydro-electric plant in the bowels of the earth. The two features of novelty in Prof. Fessenden's scheme have seemed to be the combination of windmills and solar-heat engines and the subterranean reservoir. Much interest was also aroused by his intimation that he has a 3,000-HP. plant of combined wind and sun-power apparatus under construction at a worked-out copper mine.

In view of the great interest displayed in this country and abroad in Prof. Fessenden's paper, it seems of interest to compare his ideas with schemes already worked out, like those of Mr. Frank Shuman, and of Mr. John Boyle, Jr., and Mr. H. E. Willsie (Eng. News, May 13, 1909).

In Prof. Fessenden's "solar-boiler," the water would be directly exposed to the sun's rays under the double glass roof of a building which forms really the shell of the boiler. The steam or vapor would be generated at, or near, atmospheric pressure and would be led off to a low-pressure steam turbine discharging into a condenser. Details of the design are not given, but it is stated that the water to be used under the glass roof would contain a small amount of potassium bichromate and would flow in thin streams over the floor of the absorption room, the thickness of the stream being regulated to the amount of solar radiation being absorbed at any moment. The glass of the roof would be tinged green by a slight amount of iron sulphate so as to reflect back into the interior any radiation from the water itself, while still being fairly transparent to the sun's rays. It is stated that no special provision would be made to keep the boiler particularly tight so long as it would be worked at or slightly above atmospheric pressure. We assume that the turbine would either pump water when the wind and commercial load were slight, or would furnish power direct when the wind and load were heavy.

One large windmill, or a series of smaller windmills mounted upon a turntable, is proposed for utilizing the energy of the wind, particularly when the sun is not shining. These windmills would be connected in some way by rope drives to a common shaft drive which would pass down the shaft of the proposed subterranean plant for driving pumps at the lowest level in order to elevate the water to the surface ponds,

thereby storing the energy secured from the wind.

In the Schuman scheme, a sheet of water flows along inside a structure with a glass roof, the water being covered with a thin layer of paraffine to better retain the heat absorbed. The structure is carefully designed to be tight under expansion and contraction, although the idea is not to develop vapor from the water. The hot water would be led to a great insulated storage tank, from which it was to pass to a low-pressure steam turbine discharging into a condenser.

Difficulty has been found, however, in obtaining or designing a steam turbine to operate with a mixture of steam and water. Instead, therefore, a special reciprocating engine has been built which can use steam carrying a high percentage of water and tests of it, we are informed, have shown excellent results.

In the Willsie plant, as finally built and operated at The Needles, Cal. (a 20-HP. plant), a sheet of water is also exposed directly to the sun's rays in a building having a glass roof, and is circulated rapidly through the plant. It goes to storage or flows around pipes carrying sulphur dioxide, which in turn is vaporized to drive a reciprocating engine. The dioxide-engine condenser consists of piping kept wet by trickling water, the evaporation in this desert atmosphere being sufficient to do the necessary cooling. From experience with this plant the cost of larger plants has been estimated as follows: solar heater, $100 per HP.; storage plant (for 100 hours), $10; engine and pumps, $20; dioxide vaporizer, $15; condenser, $15; sulphur dioxide, $1.25; emergency steam boiler, $2.75; total per HP., $164. The cost of power from such a plant of 400 HP. is estimated at 0.61 cts. per HP.-hr., made up of interest, maintenance, depreciation (0.19 cts.), labor (0.27 cts.) and supplies (0.15 cts.).

From the work that has already been done, it seems improbable that Prof. Fessenden will be able to regulate the flow of water through his glass absorption houses closely enough to follow the slight fluctuations of vapor pressure so as to maintain atmospheric pressure and to avoid consequent inleakage of cool air or out-flow of energy-laden vapor through his loosely built structures.

Prof. Fessenden has planned his power storage on the assumption that 1 cu. yd. of water falling through 1,000 ft. generates 1 HP.-hr. The correct energy-equivalent is really 0.853 HP.-hr. His estimate of $2.65 per HP.-hr. capacity for the cost of the concreted shaft and subterranean reservoir needs increasing therefore to $3.15. The cost of excavating and concreting in this work is claimed to be only $2 per cu. yd. of final storage space, the figure representing actual tenders. In view of the recorded cost of shaft-sinking similar to this proposition, such a figure seems too low, and between $4 and $20 would more nearly agree with results of practical experience.

It is one thing to secure an informal tender for this sort of job, involving unknown and unforeseen difficulties, at a low price per cubic yard; but it is a far different thing to push the work to a satisfactory end at that cost. Moreover, this estimate includes nothing for surface tanks. If the plant is in a desert country, the tanks must be covered or evaporation will be excessive.

Adopting the minimum figure noted, $4 per cu. yd., of subterranean reservoir, it is necessary, then, to increase Prof. Fessenden's $2.65 per HP.-hr. of storage capacity from the $3.15 just noted to $6.30.

Immediately, a great contrast is seen between the cost of Prof. Fessenden's power storage scheme and the cost of thermal storage tanks as used in the small Willsie-Boyle plant in California, where the first cost of storage plant per horsepower-hour was only 10 cts. This great contrast, of course, results from that fact that 1 B.T.U. equals 778 ft.-lbs., that is, as much energy is stored in raising a pound of water 1° F. in temperature as in lifting it 778 ft. vertically in space.

An efficiency of 97.6% for the pumps and 91% for the impulse wheels, giving a charge-discharge efficiency of 88.8%, was assumed by Prof. Fessenden. These figures, however, savor of the perfect conditions of the physical laboratory rather than conditions of actual practice. Reducing these efficiency percentages to the more probable but, for common practice, still high figures of 85% for the impulse wheels and 90% for the pumps, including the losses in driving the pumps 1,000 ft. below ground, an over-all figure of 76.5% seems to be about the most that could possibly be attained.

In the paper before the British Association, it was stated that actual tenders have placed the cost of the house serving as a "solar-boiler" at $10 per HP.; of the low-pressure turbine and condenser at $25; dynamo at $15; pumps and impulse wheel at $7.50. Nothing is said about the cost of windmills, but we may assume that this could not be less than $7.50 per HP. The principal figure surprisingly low here is the $10 per HP. for the "solar-boiler" building; it will be noted that, at the Willsie solar-power plant in California, equivalent apparatus cost $50 per HP. The total claimed, exclusive of storage facilities, appears to be $57.50, but this may be expected to rise to $80 per HP., if we add in the cost of windmills and increase the cost of the absorption apparatus to one-half the actual cost of construction in this country.

Turning attention now to the all-important cost per horse-power of mechanical power-storage plant sufficient to provide two weeks normal output, computation shows the enormous figure of $2,110, making a total of $2,190 for the whole outfit. Even this enormous figure makes no provision for the cost of the surface reservoirs for the water. However, let us pass these for the present and see what the cost per horse-power per year would be on the first cost basis just shown, $2,190 per HP.

For this computation let us accept the charges assumed by Prof. Fessenden himself, viz.: interest 4%, depreciation 2% (4% on machinery), and labor 2%. We have then a prospective power cost of $177 per HP. per year, which doesn't sound quite so much like getting power for nothing. In fact, as Prof. Fessenden himself sets down the cost of steam power as $15 per HP. and gas power as $10 per HP., the cost of his power scheme would seem to put it wholly out of the running.

The slip by which Prof. Fessenden has been led to promulgate such fallacious ideas before a distinguished scientific body was his use of only 14 hours of power storage in his computations instead of the two weeks (336 hours) which he thought he had used when he wrote:

> Measurements made during the past ten years show that it is necessary to provide storage capacity for at least two weeks, except under abnormally favorable conditions. . . . One day the idea suggested itself of using a negative instead of a positive gravitational potential. The upper reservoir would then lie on a surface of the earth. A shaft would be excavated 1,000 ft. deep, and at the bottom of this shaft, chambers hollowed out and ferro-concreted for the machinery and for the lower reservoir. . . . Estimates were obtained from three different firms of mining engineers in Philadelphia which showed that a shaft 1,000 ft. deep could be dug, properly timbered and the necessary chambers hollowed out at the bottom and ferro-concreted so as to withstand the water pressure, at a cost not to exceed 8s. per cu. yd., and tenders were made at that price for a 5,000-HP. plant. Assuming as before, two weeks' storage and an efficiency of 75%, the capital cost per horsepower-hour (*sic*) will be £7 10s.

The cost of the storage works in reality completely overshadows that of the machinery employed and this mistake is, indeed, so important that, granting every one of Prof. Fessenden's original and improbable unit costs, the actual cost of power still rises to such an excessive figure that this scheme is shown to be wholly impracticable.

LETTERS TO THE EDITOR.

Economic Comparison of Railway Tie Material.

Sir: Under the title of "An Economic Comparison of Railway Ties of Different Materials," Mr. Neil N. Campbell, in Engineering News, Sept. 22, 1910, p. 302, discusses at some length the mathematical factors relative to the cost and life of ties of various species. The saving factor in his article is the latter part of the first paragraph, which states that: "It is not the purpose of this article to arrive at any final conclusion which would apply in any locality or time, but merely to show methods of comparison and the results obtained by their use." This reservation is obvious as regards the formulas given, but it would appear that the tables do attempt to state conclusions.

The financial formulas are interesting because they point the way towards final results if worked out with definite cost figures for given conditions. Any assertion, however, that these formulas are new or original would be incorrect, for essentially the same methods, or at least the fundamental basis for them, have been used by German foresters for years in determining final results where reoccurring charges are incurred. Practically the same formulas were presented by Mr. Gilbert Alleman in a paper on "Modern Timber Preservation," published in the April, 1907, (Vol. 24, No. 2) Proceedings of the Engineers' Club of Philadelphia. Mr. Alleman gave credit for his mathematical statements to Prof. John A. Miller, of Swarthmore College. The same results were presented by Mr. Alleman in much more convenient form in tables showing the annual charges against ties if the original cost, life, and relaying charges are known.

In the tables in Mr. Campbell's articles which show comparative values of ties of different materials with and without the use of tie plates, it seems evident that erroneous conclusions are drawn. The basis for the conclusions is the life of the ties and their cost. The text states that Table I shows the average life and cost in track of ties used on representative railroads over the United States, having a total mileage of 62,309. Table II is supposed to show the same data, except that tie plates are used, and it is assumed without apparent basis that the ties will resist mechanical wear as long as they resist decay. Without questioning the source of the information given, it is certain that average figures on life and cost of ties are of no value, because it would mean that the life of ties under heavy wheel loads and dense traffic on one road is averaged with the life under conditions elsewhere which are much less severe, giving a figure which means absolutely nothing under any given condition. The same is true as regards cost. Again, in the table where it is assumed that tie plates are used, nothing is said as to the size and design of the plates, and on this factor alone would depend whether the ties wore out before they decayed.

As regards the influence of treatment, the comparisons between untreated, straight creosote, and Rueping are purely academic, because it is certain that there is no compilation, nor has a complete series of tests ever been made, showing comparative results with the straight creosote and the Rueping process on all of the species named. In fact, the Rueping process has been in practical use only about seven years; so to say that it will preserve a beech tie 15 years as against 17.5 years with straight creosote, is stating an unproven theory. As a matter of fact, beech ties in France give 28 years' service with full-cell creosote treatment. Table II shows a difference in life of 6 years between untreated and creosoted locust, and also assumes the creosoting of hickory. Locust is one of the hardest and most durable woods, and not only will not creosote readily, but does not need it; while hickory is a negligible factor as a tie timber, and is almost as impervious to creosote as metal.

The most misleading statement of all is regarding catalpa, and to give it first place, untreated, in comparison with treated or untreated wood of other species is decidedly unfair. The heartwood is acknowledged to be resistant to decay, but the thin sap rots quickly, and the wood is so soft that even under moderate traffic it would no doubt be worn out long before 20 years had elapsed. Moreover, the timber is not plentiful, and authoritative evidence that catalpa ties have ever been used on a commercial scale, or are as lasting as the catalpa enthusiasts claim, is lacking. It is significant that of the fifty railroads which reported to Engineering News in 1908 (June 4, 1908, p. 602) regarding standard practice as to ties, not one reported the use of catalpa.

Yours very truly,

E. A. Sterling.
Forester, Pennsylvania R. R.

Philadelphia, Pa. Oct. 27, 1910.

Method of Measuring Concrete Work.

Sir: The "Chicago Rules for Measuring Excavation and Concrete Work" published in Engineering News, Nov. 3, p. 492, should be of interest to all contractors and engineers who do any work on a unit price basis, or who are engaged in estimating and computing costs of work.

There has evidently been a serious endeavor to construct formulas, or rules, which shall automatically adjust themselves to the cost of varying classes of work. It is greatly to be regretted that these formulas are based upon a wrong conception of the various distinct and separate labors which go to make up the cost of concrete work, and these, in consequence, will undoubtedly prove a source of trouble and dispute as soon as they are in force.

The writer holds that the fundamental law of measurement is, *that all quantities of materials and labor should*

be measured net as finally left in the building or structure, and that all extra labors and waste, etc., should be allowed for in price and not in measurement. It follows from this law, that works of a temporary character should not be measured unless they form a distinct labor item which can be separately measured. Thus, we do not measure staging for brick masons, sheeting for trenches, etc.; but we do measure forms for concrete, because they are a separate and distinct operation or labor item necessary to the construction of concrete work. It also follows that work requiring more than an ordinary amount of labor to perform should be priced separately, and not paid for by an excess measurement of the ordinary work, and therefore, a concrete pier 1 × 1 × 10 ft. should not be priced as 70 cu. ft. of concrete in mass foundation work, but should be priced as 10 cu. ft. at a higher price than the foundation of concrete.

One of the objects of the framers of the "Chicago Rules" appears to be to eliminate all measurement of forms to concrete work, allowing an excess measurement of concrete to pay for the same. Presumably one difficulty is that of measuring something that cannot be seen when the building is finished, another difficulty is that there is no established unit of measure for forms, and if board feet of lumber are measured, the engineer is afraid that his owner's interests will suffer, as he has no check upon extravagant use of lumber. It is the practice of the writer's firm to measure and value all form work by the square foot of surface contact, and we believe that this method is superseding the old method of reckoning by board feet, which is still in use by many large firms. The square foot of surface does give a definite and unchanging unit to measure. There are always the same number of square feet to center in the under side of a floor, although the lumber used on similar work by different companies may vary.

We think the Associations who have adopted these rules would have done far better if they had recognized the item of form work as a separate item, and devised a separate method of measuring and valuing it, and further, better results would have been attained if they had constructed some rule which should adjust the price according to the character of the work done, rather than inflate the measured quantity of small or thin pieces of concrete work. We believe that it will not be difficult for an unscrupulous contractor to take an unfair advantage of these rules, and that in endeavoring to simplify and codify the measurement of concrete work, they have added to rather than lessened their troubles.

An instance of the actual working of the rules may be of interest—Assume a reinforced-concrete floor slab 100 × 50 ft. and 4 ins. thick carried by 20 reinforced-concrete beams 50 ft. long, each 12 × 12 ins. in section below the slab, the beams resting on 80 concrete columns 10 ft. high and 12 ins. square; actual quantity of concrete, 3,467 cu. ft.; quantity according to the rules, 13,100 cu. ft. As another instance: assume a concrete wall 6 ins. thick, 100 ft. long, 10 ft. high, with ten pilasters 18 × 8 ins. projection; actual quantity of concrete, 600 cu. ft.; measurement according to rules, 1,550 cu. ft.

We suggest that though engineer and contractor measure in good faith, it would be exceedingly difficult to convince any hard-headed board of directors, or zealous municipal reformer, who had troubled to look into the matter, of the accuracy and justice of such measurements as the above.

Our object in calling attention to this is two-fold: That we desire to protest against the possible general adoption of similar codes framed upon wrong lines, and we want to call attention again to the fact that form work is a separate item in all concrete work, and until this is recognized, and the contractors and engineers measure and price same separately in unit price contracts, trouble and unfairness to one side or the other is bound to result.

Yours truly,

Leslie H. Allen.

Aberthaw Construction Co.

8 Beacon St., Boston, Nov. 10, 1910.

Flies and the Disposal of Garbage and Refuse.

Sir: In your issue of October 20, p. 419, you referred in an editorial note to a report by the writer as Chairman of the Street Cleaning and Garbage Disposal Committee of the American Society of Municipal Improvements, in which you placed considerable emphasis on one of its minor points, namely, a reference to the transmission of disease by flies which delight to make their habitat in decaying organic matter.

The writer is always glad to be "set right" upon any question, when he is in error, but the weight of evidence of progressive investigators of the present day, both in this country and abroad, substantiates more and more conclusively the charges brought against the fly. It is not at all necessary for the writer to take up the discussion, for many far abler men have given to the subject large investigation, and their published reports, verifying fully the premises, can be readily secured.

The discussion of such questions should rarely be indulged in by those who have simply read reports, for those competent to discuss them are the men who have had opportunity for direct investigation and can speak, therefore, from personal experience.

The writer, however, stated in the report to which you have referred that he was not discussing the question of disease transmission by flies, but mentioned it incidentally as one of the features to which many communities were devoting investigation.

While commenting on this general subject, the writer will venture to call attention to another matter discussed at the convention, namely, the advocated feeding of garbage to hogs as an excellent means of disposal. It is granted, without objection, that the feeding of fresh garbage, untainted, may be desirable, but surely no one familiar with the handling of garbage can for one moment maintain that the refuse that reaches the hog pen, as gathered in communities, is ever in a fresh and sanitary condition.

Your attention could be called to at least one instance where hogs have died in numbers after feeding on municipal garbage, and to such a case where the farmer's only regret was that he did not discover the dying condition of his hogs in time to kill them, so that their bodies might be sent to market instead of to the offal heap.

The writer has taken up this subject with those directly interested in many places, and the almost universal sentiment is that for the best interests of the community the practice of feeding garbage to hogs should be absolutely prohibited by law, not because fresh and sanitary refuse or swill would be harmful, but because of the practical certainty that when such material is delivered it is unfit even for hogs to eat.

Yours very truly,

Louis L. Tribus,

Consulting Engineer and Commissioner of Public Works, Borough of Richmond, New York City.

[We do not question the existence of published and unpublished *opinion* to the effect that the garbage-fly combination is a means of spreading disease. What we do question is the existence of *scientific proof* that there is sufficient danger from the combination to warrant serious consideration and any considerable extra expense in connection with garbage disposal methods.

As to feeding city garbage to hogs, we see nothing in our correspondent's assertion to prove that the practice is a menace to public health. Stories about the wholesale death of garbage-fed hogs have no special significance unless the real cause of death is fairly established; and once it is proven that partly decomposed garbage is death to hogs no one pecuniarily interested is likely to feed it to them. Anyhow, a moderate amount of city or state sanitary inspection would guard against such danger as might exist. But supposing garbage did kill hogs and the deceased were converted into ham, bacon, sausage or salt junk, what would happen to the eater thereof? We do not ask the question because we advocate the marketing of meat from animals that have come to an untimely death, but simply because in the sentimental as opposed to the scientific discussion of current sanitary matters so much is taken to be a menace to the public health which is founded on old-time notions which associated disease with filth and odors. Such notions were and are all right for those who had or have no other index of health dangers than the eye and nose, but engineers and other scientists should base their theories and practice on something more definite, whenever it exists.—Ed.]

Lengths and Deflection Angles of Transition Curves.

Sir: The article by Mr. C. P. Howard in your Oct. 13 issue, on "How to Run in Transition Curves Without Tables," prompts me to submit a formula for the length of spiral, which I developed several months ago while converting tables of spirals into metric units for use in Mexico.

Using the following notation:

E = elevation of curve in inches.
g = gage of track.
V = velocity in miles per hour.
v = velocity in feet per second $= \frac{22}{15} V$
D = degree of curve.
R = radius of curve.
L = length of spiral in feet,

the formula for theoretical superelevation is,

$$E = \frac{g\,v^2 \times 12}{32.16\,R} = \frac{g(\frac{22}{15}V)^2 D}{32.16 \times 5730} \times 12$$

$= .0001404\ DV^2g$
$= .000661\ DV^2$, when $g = 4$ ft. 8½ ins.
$= .000689\ DV^2$ for 85-lb. rail with $2\,^9/_{32}$-in. head.
$= .000685\ DV^2$ for 55-lb. rail with 2¼-in. head.

Prof. A. N. Talbot's formula, $E = .00069\ DV^2$, is based on the fact that the track level gage is the width of the rail head wider than the track gage.

The reports on spirals from all the main roads in the country to the American Railway Engineering and Maintenance of Way Association in 1909 brought out the fact that the maximum rate of attaining elevation on curves without discomfort to passengers is about $1^1/_6$ in. per sec. on tangent and spiral, and according to the New York Central report by C. J. Parker, Prin. Asst. Engr., $^5/_6$ in. per sec. where the runoff is on straight track (see pp. 420, 422, Part 1, Vol. 10 of the A. R. E. & M. W. Assoc. Proceedings).

Since the elevation of the curve is E inches, at the rate of $1^1/_6$ inches per second it would take $\frac{E}{1^1/_6}$ or $^6/_7\,E$ seconds to attain the full curve elevation. The distance traveled in attaining this elevation would be $\frac{6}{7}\,E\,v$ feet.

Therefore the length of spiral,

$$L = \frac{6}{7} E\,v$$
$$= \frac{6}{7} \times .00066\ DV^2 \times \frac{22}{15} V = .000830\ DV^3$$
$$= \frac{DV^3}{1200}$$

Calling a the rate of change of degree of curve in 100 ft.,

$$a = \frac{100\ D}{L} = \frac{120000}{V^3}$$

To find the formula for any other rate multiply the above formula by the inverse ratio of the new rate to the rate of $1\,^1/_6$ ins. per sec.

The run-off rate of $^5/_6$-in. a second requires that

$$L = {}^7/_8 \times .00083\ DV^2 = .00116\ DV^2,$$

Using Prof. Talbot's formula for elevation, $E = .00069\ DV^2$, and a rate of 1 in. per sec., the formulas are,

$$L = \frac{D\,V^3}{1000} \text{ and } a = \frac{100000}{V^3}.$$

The values found from the above agree with his recommended lengths of spirals for different speeds.

It is my opinion that the spiral should receive the same grade compensation as the curve with which it connects as a rough allowance for the extra resistance on the spirals due to the force required to twist the trucks, change the relative position of the cars, and attain the curve elevation.

Robert S. Beard.

Kansas City, Mo., Oct. 16, 1910.

Sir: Referring to Mr. C. P. Howard's article on Transition Curves in your issue of October 13, let attention be called to the fact that:

If the curve be laid in with six equal chords, the deflection for the first chord in *seconds* is the length of the chord in *feet* multiplied by the degree of the central curve, and the following deflections are 4, 9, 16, 25, and 36 times this.

If the curve be laid in with ten equal chords, the first deflection in *minutes* is the length of the chord *stations* multiplied by the degree of the central curve, and the following deflections are as before.

These are both approximate rules, but entirely good for spirals whose total central angles do not exceed 15°. Both rules are given in the subscriber's "Railroad Field Geometry." The second rule is due to Mr. Jenks B. Jenkins.

Wm. G. Raymond.

State University of Iowa, Iowa City, Oct. 28, 1910.

ELECTRIC HEADLIGHTS ON ELECTRIC CARS of interurban railways were included in the investigations of the Indiana Railway Commission as to the use of high-power (electric or acetylene gas) headlights on locomotives. The motormen who gave evidence were uniformly in favor of the electric light as a safety device, enabling them to see obstructions on the track at sufficient distance to allow of the cars being stopped before collision occurred. They estimated that the light illuminated the track for a distance of about 1,000 ft., and that cars traveling at 50 and 55 m. p. h. could be stopped in 700 to 1,000 ft. on emergency. Several of the witnesses cited cases where accidents were avoided in this way, but which could not have been avoided if the cars had been equipped with oil headlights. There is very little trouble from the motormen being dazzled by the lights on opposing cars or being unable to distinguish signals and markers in the light from their own headlights. In cities and towns, the light can be screened or reduced. The evidence indicated that a high-speed service of electric cars could not be maintained safely without the use of high-power headlights. The above particulars are taken from the annual report of the Indiana Railway Commission. While the use of electric headlights is somewhat exceptional on steam railways, it is practically universal on electric railways. The tests, conducted for the Indiana Railway Commission and in which high-power locomotive headlights were shown undesirable, were described in Engineering News, April 21.

The First Garbage Reduction Works Built by an American City; Columbus, Ohio.

By I. S. OSBORN.*

On July 20, 1910, the city of Columbus started the operation of the first municipal reduction plant designed and constructed by a municipality for the disposal of garbage. The majority of the larger cities in the United States have their garbage disposed by the reduction process under contract with private companies. The only other garbage reduction plant owned and operated by a municipality was purchased by the city of Cleveland, Ohio, in 1905, from the Newburg Reduction Co., who formerly had disposed of the city's garbage by contract. It was the only municipal plant of this type in operation until the starting of the Columbus plant.

From a commercial standpoint the reduction of garbage has in most cases proven successful, although failures have occurred in this as well as in other methods of disposal, due to faulty design and lack of proper attention and management.

From a sanitary standpoint the reduction of garbage has been looked upon as being very undesirable, due largely to the manner in which the plants have been constructed and operated. This will continue to be the case as long as cities contract for the disposal for a short term of years. The contractor cannot afford to install an expensive plant, or pay much attention to the design from a sanitary standpoint. Under contract it is considered chiefly from a commercial standpoint, which consists in obtaining the largest remuneration possible at the least cost.

INCEPTION OF THE PROJECT. — Previous to April, 1906, the city of Columbus contracted for the collection and disposal of garbage. The contract has proven very unsatisfactory, in poor collection service and in the nuisance caused by odors from the reduction plant. The plant was one of the early types and was constructed at small first cost, with little regard for the sanitary features, because the small amount paid the contractor was not sufficient to even pay for the cost of collection.

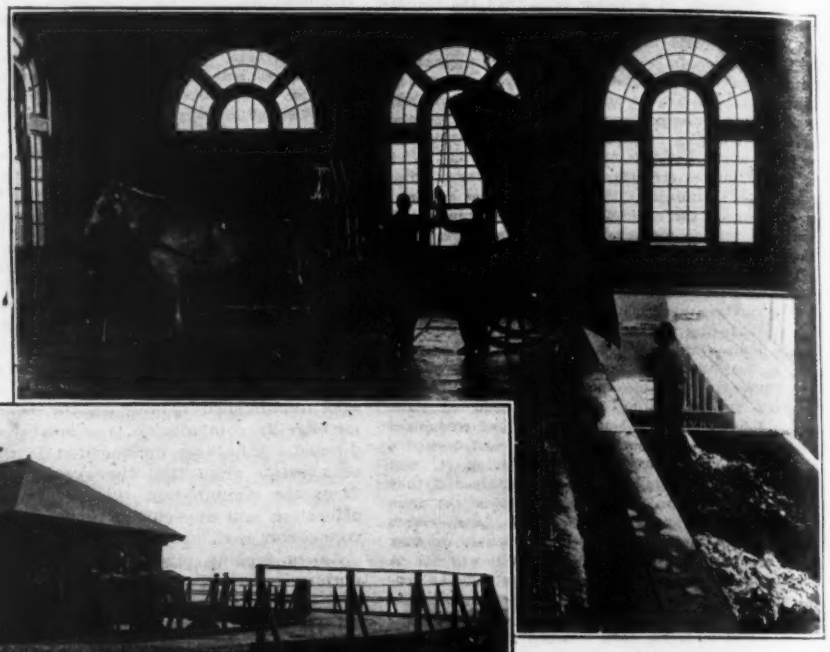
At the expiration of the contract in April, 1906, the city installed a municipal collection system and disposed of the garbage by burying it on what is known as the English farm, located about one mile southwest of the city limits, which is owned by the city. This method was continued up to the time of starting the reduction plant.

After making an extensive study of the garbage problem, the city at the expiration of the contract issued bonds amounting to $290,000 to cover the cost of a disposal plant and collection equipment. The city officials decided to contract for a crematory and dispose of all garbage and refuse by cremation. Before the plans were carried out a change of administration took place and the newly elected officials decided to contract for a complete reduction plant so as to obtain by-products from the garbage, which would make returns that could be applied on the cost of disposal. After advertising twice and not receiving satisfactory bids, the city decided to design the plant and contract for the several parts separately. By this plan it was able to accept such machinery and equipment as had proven most satisfactory and at the same time not be dependent on any one particular patented process.

In designing the Columbus plant the first object was to make it as sanitary and as free from undesirable features as possible, and at the same time to make the appearance of the buildings and layout of the plant agree favorably with other municipal improvements. The plant is designed with sufficient capacity to take care of the future growth of the city for a period of 20 years. The capacity is about double the amount of garbage collected at the present time. As the city grows the plant will operate a larger force and more hours per day.

COLLECTION AND SHIPMENT.—The garbage is collected in wagons which have watertight steel bodies and sectional canvas covers, and is hauled to a central loading station, located on the Hocking Valley R. R. near Mound St. (figs. 1 to 3). The wagons number 34, of which on the average 25 are in regular service.

The loading station consists of a building 40 ft. wide by 90 ft. long, with a railroad track extending through, which allows two cars to stand inside the building when the large track doors are closed.



Dumping Wagon Into Car.

The Loading Station.

FIGS. 1-3. COLLECTING GARBAGE AND LOADING FOR SHIPMENT TO REDUCTION PLANT, COLUMBUS, O.

Covered Garbage Wagon.

The wagons are drawn up an incline driveway on to the second floor of the loading station, and by means of power hoist the front of the wagon body is elevated, discharging the garbage out of the rear end into the garbage cars below. All work at the loading station is carried on inside of the building, so as not to cause any complaint from the surrounding community on account of unsightly appearance or odors.

Adjoining the loading station are the stables for the collection department, having a capacity for stabling 100 horses. The offices of the collection department and a locker bathroom for the men are placed on the second floor of the stable.

The cars are constructed with semicircular bodies, especially designed for hauling garbage. The body is mounted on trunnions to allow turning when being unloaded. The cars are four in number and have each a capacity of 1,400 cu. ft., or 40 tons. Two cars are at the loading station while the other two are being unloaded at the reduction plant.

Between seven and eight o'clock in the evening, each day's collection is delivered at the reduction plant by the railway, and the empty cars, after being thoroughly cleaned, are returned to the loading station.

The Reduction Plant.

The reduction plant is located about four miles south of the center of the city on the

*Engineer-in-Charge, Garbage and Refuse Disposal, Board of Public Service, Columbus, O.

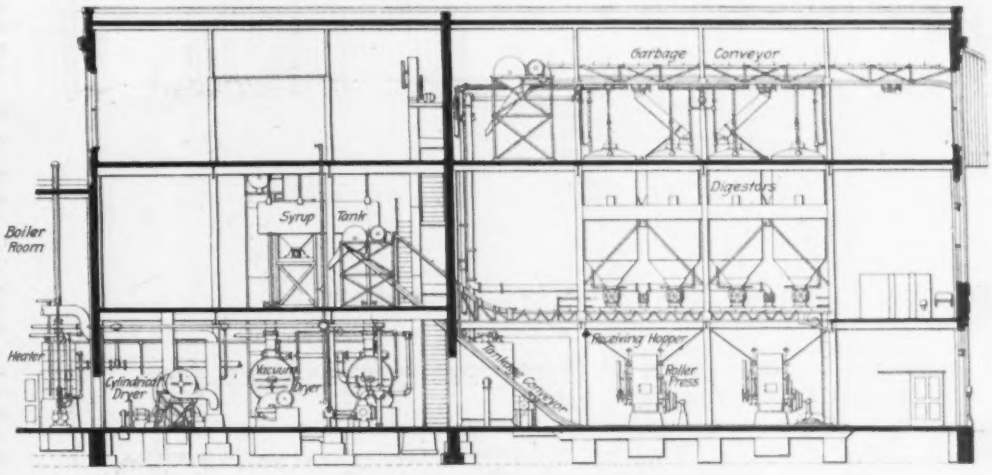
Scioto River, adjoining the sewage purification works.

The railway tracks at the plant are on top of the levee which surrounds the building site, about 10 ft. above the ground floor of the buildings. This elevation allows all material coming to the plant to be discharged from the cars by gravity. The coal is discharged from side or bottom dump cars into the storage bins in front of the boilers.

At the plant there are four buildings: Main Building, 162 ft. by 76 ft.; Green Garbage Building, 90 ft. by 40 ft.; a small office building, and a stable.

RECEPTION OF GARBAGE.—The garbage when delivered at the plant is weighed on the railway track scales and is then run into the Green Garbage Building, which has railway tracks extending through it. The body of the car is then turned on the trunnions by means of power hoists and the contents are discharged on the sorting floor below. The free water is drained off through a gutter extending the full length of the building, covered with perforated plates. The swill water from the gutter is drained into a catchbasin, from which it is discharged into the grease-separating tanks and then evaporated.

The garbage is sorted, and is then shoveled into a 24-in. scraper conveyor, which extends the full length of the Green Garbage Building. Connecting the Green Garbage Building with the Main Building is an incline truss which carries the garbage conveyor to the top of the Main Building and then along the bottom chord of the roof trusses and over the tops of the digestors. Swivel spouts from the conveyor to the digestors enable the garbage to be discharged directly into the digestors.



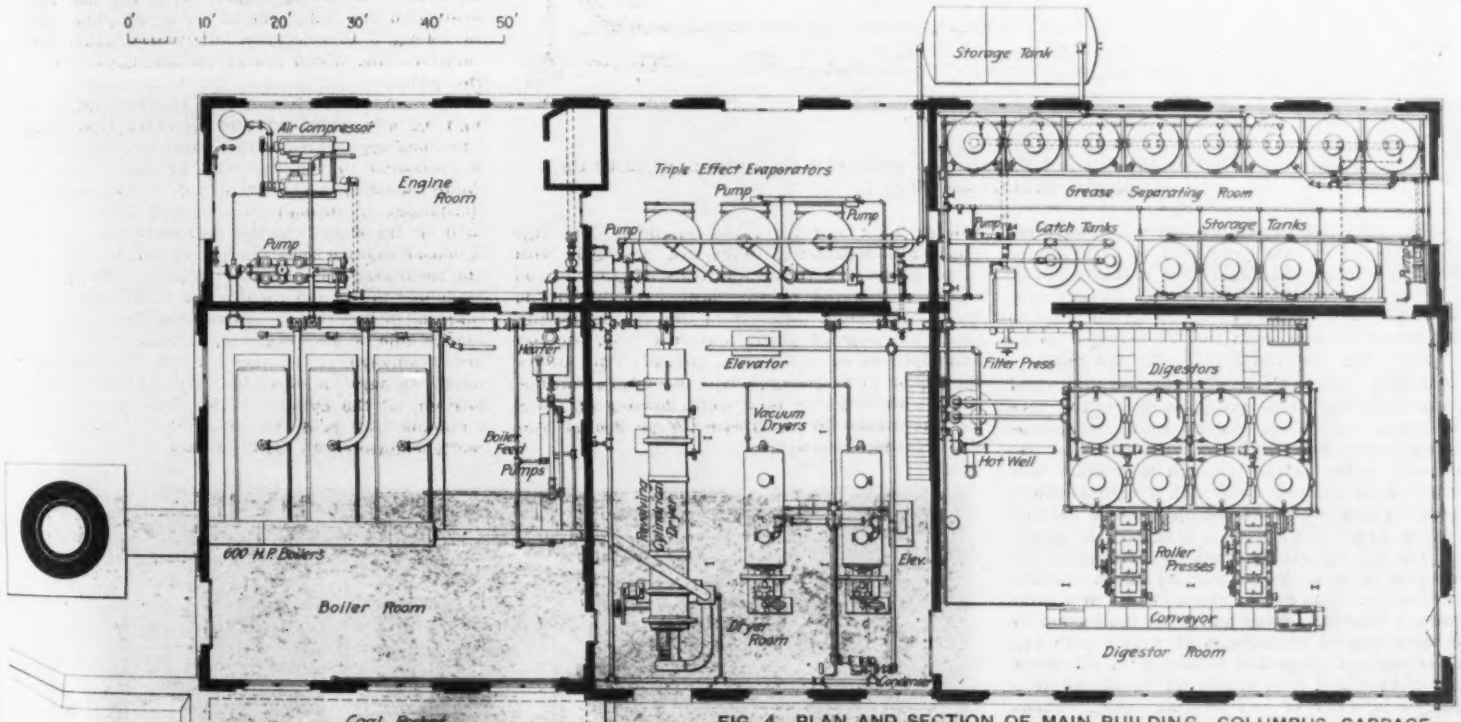


FIG. 4. PLAN AND SECTION OF MAIN BUILDING, COLUMBUS GARBAGE REDUCTION PLANT.

DIGESTORS.—The digestors are eight in number. Each digestor is 7 ft. in diameter by 14 ft. high, is constructed of ⅝-in. flange steel, and has a capacity of from ten to twelve tons of garbage. The inside is lined with cement and tile 1½-ins. thick, so as to protect the digestors from wear due to the agitating of the gritty material when boiling, and at the same time resist the action of the acids which would attack the metal. At the top of each digestor is a round 18-in. cast-iron inlet door and frame, and on the bottom is placed a 16-in. flanged outlet for attaching the discharge valve.

The outlet castings are tapped on opposite sides for pipe connections through which live steam is admitted for cooking. The steam is turned into both connections at the same time, and as the discharge from the steam nozzles comes together the steam spreads and circulates through the mass. The top of the digestor is connected by a brass pipe to a condenser. When cooking, the steam is allowed to escape through a ¼-in. by-pass, so as to insure againt the digestor becoming air-bound and thus prevent the steam from entering.

The digestors are arranged in nests of four connected to a common receiving hopper by a large gate valve and nozzle on the bottom of each digestor.

The garbage when cooked is discharged through the valve into the receiving hopper, which is directly above a roller press. Four digestors together with one receiving hopper and one roller press form a unit.

The vapors arising from the mass in the receiving hopper are conducted by a vent line to a condenser, which with the condensers for the digestor is connected to a vapor-tight steel hot-well. Any odors carried by the gases and not taken up in the condensers are trapped in the hot-well and then passed by a vent line to the boiler furnaces.

The time required for cooking varies with the quality of garbage, but averages about six hours, with steam at 60 to 70 lbs. pressure as it enters the digestor.

PRESSES.—The presses which are connected to the receiving hopper are of the continuous roller type. They were designed by Mr. Charles Edgerton, especially for handling garbage. The presses are constructed throughout of cast-iron, wrought-steel and cast-steel, with renewable wearing strips, take-up boxes and cleaning brushes. Each press is enclosed in a vapor-tight cast-iron housing approximately 28 ft. long by 3 ft. wide by 7 ft. high. It is connected directly to the bottom of one of the two receiving hoppers, so that the material from the digestor passes through the press before being exposed. The press is provided with an upper and lower conveying apron. The upper apron, composed of ½-in. steel slats and heavy forged steel chain, acts as the bottom of the receiving hopper; when the press is running it carries the material through a feeding roll and discharges it on to the lower apron. The lower apron is composed of perforated slats ⅝-in. thick, riveted to forged steel chain. The lower apron passes between three pairs of cast-iron rolls 28 ins. in diameter, controlled by heavy steel springs, so that they may be regulated to any desired pressure depending on the quantity of material to be passed

through. The pressed material is discharged at the front of the press into a scraper conveyor which carries it to the second floor of the drying department.

The press is driven by belt from a countershaft, which in turn is driven by a 7½-HP. motor, directly connected by a spur gear. The pressing rolls are driven by chains. The press is constructed so that one apron or both can be operated. On the feeding roll is a safety device to protect the machine should any foreign substance get back of the roll which is too large to pass through. The press can be reversed so as to remove any material from under the rolls.

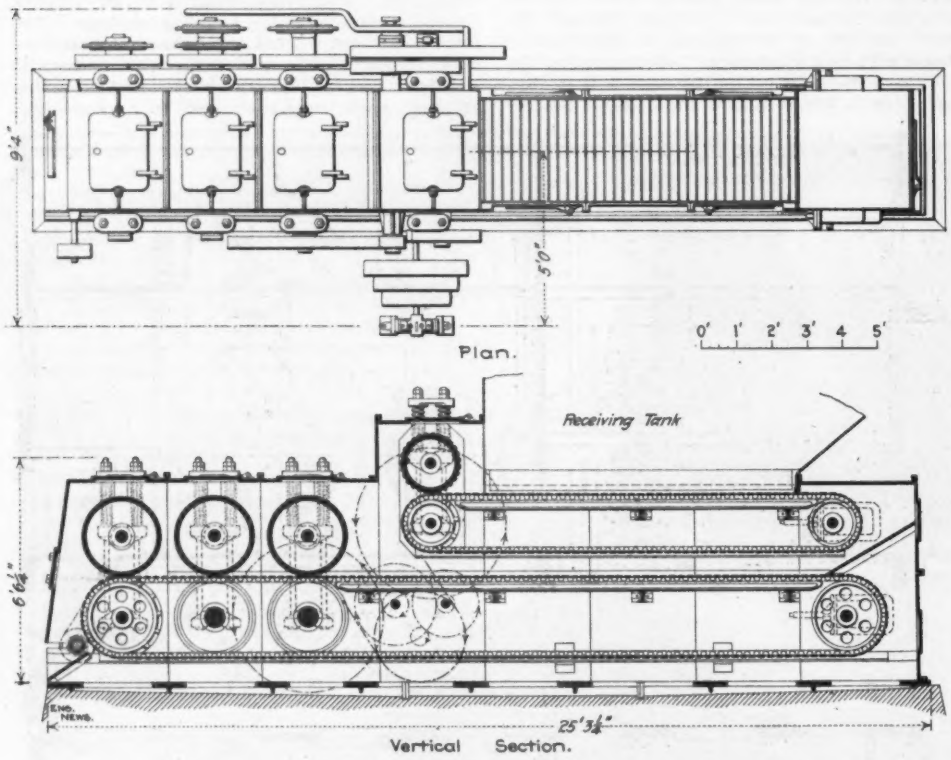


FIG. 5. GENERAL DRAWING OF ROLLER PRESS FOR DIGESTER DISCHARGE, COLUMBUS GARBAGE REDUCTION PLANT.

GREASE SEPARATION.—The water and grease flow back from the press through a covered conduit to the catchbasins in the grease-separating room. The catchbasins are set below the floor and in the bottom of each is a small motor-driven centrifugal pump with a vertical shaft. The water and grease are pumped into a battery of tanks where the grease is separated by gravity. The six separating tanks in the battery are connected in series by an 8-in. by 12-in. opening near the top. The grease rising in the first tank overflows into the second and from the second to the third, and so on through all tanks, with the largest amount of grease collecting in the sixth tank, from which it is drawn off by means of a pipe line into one of two treating tanks. These treating tanks are each 7 ft. in diameter and 12 ft. high, and are constructed with flat tops and cone bottoms.

The liquor from the presses carries more or less solids in suspension. These solids are known as muck and silt. The muck settles to the bottom of the tanks and the silt rises to the top of the water below the grease. By means of pipe connections the muck and silt are drawn off by a magma pump and discharged into a muck tank, which is similar in design to the separating tanks. The muck and silt are drawn off from the muck tank and then placed in a screw press, from which the liquor flows to the catchbasins and the solids are placed in the conveyor leading to the dryer room.

The grease drawn off from the separating tanks is heated up in the treating tanks in order to separate the impurities, and is then pumped into storage tanks ready for shipment. The grease storage tanks are four in number with a total capacity for storing 15,000 gallons of grease. They are so piped that the grease can be pumped to each tank or can be drawn off and pumped into railroad tank cars for shipment.

TANK WATER.—The tank water after the grease has been separated is drawn off to a large storage tank outside of the building. The first and sixth separating tanks are provided with large control valve so that the liquor can be raised or lowered to any desired height in the tanks. The tank water from the last separating tank is drawn off about four feet from the top and piped so as to trap the grease. This allows the liquor to be pumped into the tanks continuously with only the tank water flowing off, leaving the grease to be drawn off as desired into the treating tanks.

FIG. 6. VIEW IN DIGESTER FLOOR, SHOWING CONVEYOR AND FEEDING SPOUTS.

The tank water contains from 5% to 7% of solids in solution; it is evaporated in a triple-effect evaporator. The evaporator is made up of three round-bodied cast-iron pans, 8 ft. in diameter, built especially for the conditions to be met in handling garbage tank water. All the parts that come in contact with the liquor are made extra heavy. The third pan is constructed with a special bottom for removing the solids that accumulate. The total heating surface in the three pans is 2,554 sq. ft., made up of horizontal 2½-in. by No. 14 (old gage) brass tubes. These are secured in position by means of gaskets and packing rings. The evaporator is capable of concentrating 1,500 gals. of tank water per hour from 7° Be. to 22° Be., using exhaust steam at 5 lbs. pressure on the first pan and a vacuum of 25 ins. on the third pan. By use of the round bodies all internal bracing is made unnecessary and the pans can be constructed with fewer joints. Each effect is equipped with an internal separator to prevent intrainment, and has a manhole, a vacuum breaker, a vent pipe, four peepholes, internal electric light, and the necessary gages.

The condensation is handled by condensation pumps. The concentrated syrup is drawn off by a magma pump, discharging into a storage tank on the second floor of the drying department. The feed pump to the evaporator is provided with a neutralizing gear and is connected to a tank containing a neutralizing solution; by this means the required amount of solution is mixed with the tank water to neutralize the acid so as to prevent its attacking the metal. The vacuum is maintained by an 8 × 12 × 12-in. condensor pump of the injection type.

TANKAGE DRYERS.—The solids from the roller presses which have been delivered to the second floor of the drying department are fed into a revolving cylindrical dryer. This dryer is constructed with a steam jacket and the inner shell is provided with lifting angles in short lengths arranged so as to have free expansion and contraction. The lifting angles carry the material well up on the rising side of the dryer. The heat for drying is obtained from the steam jacket and radiator coils, which are at the discharge end of the dryer.

The radiator consists of four sets of coils, 5 ft. high by 6 ft. wide, made of standard 1-in. pipe. The coils are covered with a steel housing which is connected to the rear end of the dryer. A small cast-iron blower attached to the housing discharges air through the coils and then into the shell of the dryer. At the feed end of the dryer is placed another cast-iron blower which exhausts the saturated air and discharges it through a condenser tower and then to the boiler flue. The material to be dried is fed into the dryer continuously and is discharged by means of a short spiral conveyor at the opposite end. The material passes through the dryer by virtue of the inclined position of the cylinder. The shell revolves on trunnions and is driven by a 10-HP. motor directly connected by spur gearing.

The dried material from the revolving dryer is then elevated and passed through a revolving screen. The screened tankage is next placed in the vacuum or mixing dryers and the concentrated syrup from the evaporator added. The dry fibrous material acts as a filler and enables the moisture in the syrup to be driven off. The addi-

tion of the syrup to the fibrous tankage produces a higher grade of tankage from a mechanical and fertilizing standpoint.

The vacuum dryers, two in number, are 60 ins. by 15 ft., constructed with outer and inner shells with a 2-in. steam space between. Passing through the dryers is a shaft to which paddles are attached for agitating and mixing the material. The vacuum is maintained by an 8 × 12 × 12-in. jet condenser pump. When dry the material is discharged into a spiral conveyor connected to an elevator, which discharges the tankage on the third floor. Here it is stored until shipment.

FUTURE PERCOLATING PLANT.—The city now has under construction a percolating plant for use in extracting the grease from the dry tankage, as only about half of the grease is recovered where the press system is used. The percolating plant will consist of extractor tank, vaporizers, condenser, and storage tanks, and is to be located in a building just west of the Main Building.

POWER EQUIPMENT.—An independent motor is connected to each power-driven unit, operating with 440-volt, 60-cycle, two-phase current. The current for both lighting and power is furnished by the Municipal Light Plant, at a cost of 1½ cts. per KW.-hr.

The boiler plant consists of three 78-in. by 20 ft. horizontal tubular boilers, with two boilers in service and the other in reserve.

BUILDINGS.—The buildings are constructed fireproof throughout, having concrete foundations, steel frame and roof trusses, reinforced-concrete floors, brick walls and hollow terra cotta tile roof covered with four-ply felt-and-asphalt roofing material. The exterior and interior walls of the building are laid up with a high grade impervious hard-burned wire-cut face brick. The construction of all parts so far as possible was made to agree with the best modern practice employed in building construction.

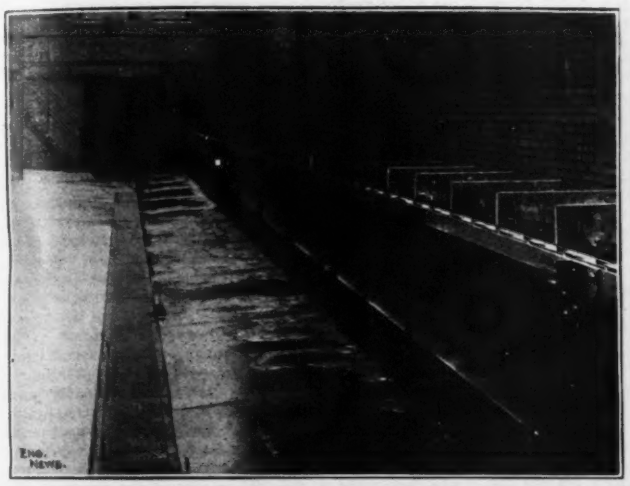
COST.—The cost of the plant is approximately $180,000, divided as follows:

Grading and Levee	$11,000
Buildings	76,000
Garbage Machinery	60,000
Power and Conveying Machinery	30,000
Railroad Tracks	3,000

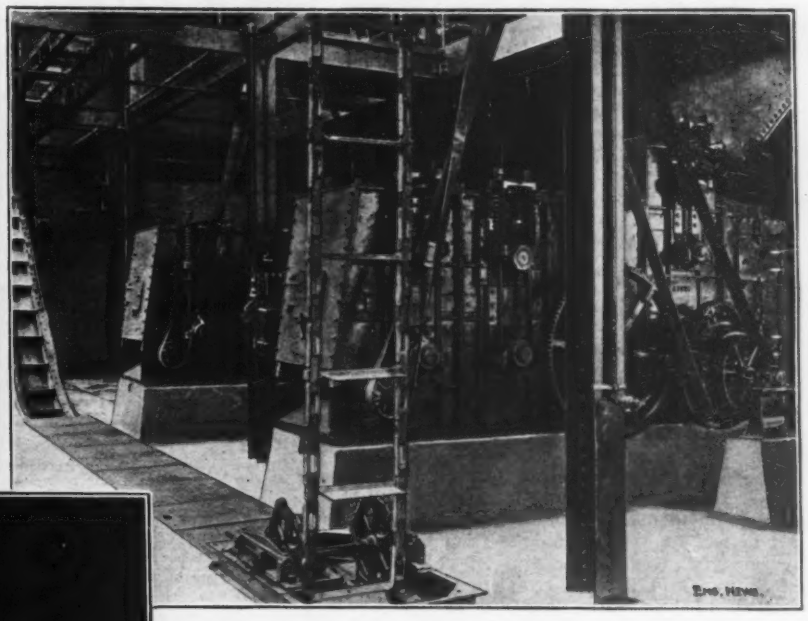
The construction of the plant, including the buildings and machinery, was carried on under ten separate contracts. The buildings were built by D. W. McGrath, of Columbus, O. The power plant and power equipment was installed by the Wm. H. Conklin Co., of Columbus, O. The digesting, pressing and grease separating machinery was furnished by the Kutztown Foundry & Machine Co., of Philadelphia, Pa. The conveying machinery was installed by the Jeffrey Manufacturing Co., of Columbus, O. The drying machinery was installed by the C. O. Bartlett & Snow Co., of Cleveland, O. The evaporator was installed by the Zaremba Company, of Buffalo, N. Y.

The Columbus plant contains very little experimental machinery, although in a number of ways it differs from other reduction plants. The chief difference is in the separation of the grease in closed vertical tanks and the condensing and deodorizing of the gases. Evaporating the tank water in a triple-effect evaporator is entirely new in the disposal of garbage, although used extensively on the tank water at the larger packing houses. It was not the intention in designing the Columbus plant to try experimental machinery, but rather to assemble to best advantage machinery of known and tried types and only such as had proven most satisfactory in other plants. The plant was not designed with the idea that in handling such a low grade material it could be made to pay for the cost of collection and disposal, but with the idea that the garbage could be by this method disposed of at the least cost and at the same time in a sanitary manner.

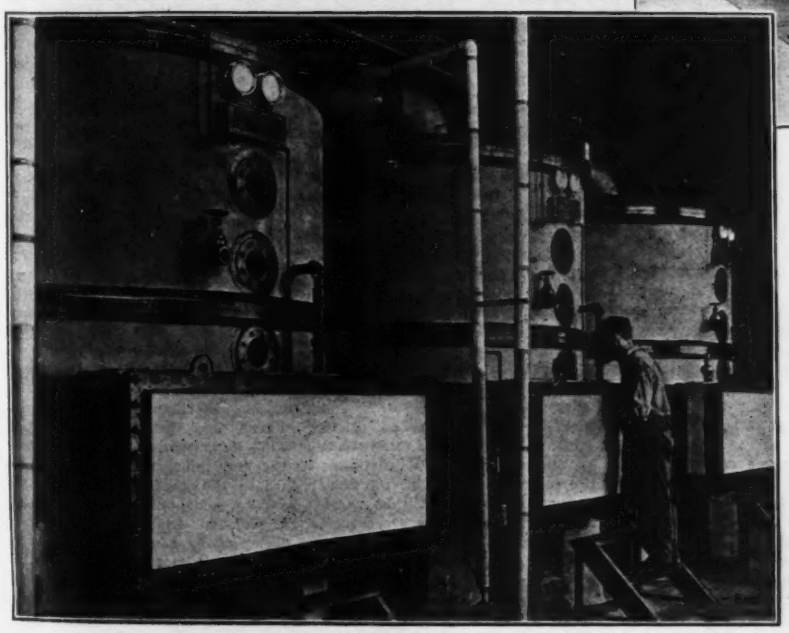
After three months' operation the plant has more than met expectations, as the returns from the sale of by-products have more than paid for the cost of disposal. The results obtained must be left until the plant has been in operation several months and has had a chance to demonstrate what results can be obtained in the reduction of garbage from a financial and sanitary standpoint.



Garbage Conveyor in Green Garbage House.



Roller Presses.



Triple-Effect Evaporators.

FIGS. 7-9. THE COLUMBUS GARBAGE REDUCTION WORKS.

CONCRETE LAYING AT PANAMA, especially on the Gatun and Pedro Miguel locks, is progressing at a rapid rate. Regarding the former the "Canal Record" says:

Concrete work in Gatun Locks is about 40% completed, 865,524 cu. yds. out of a total of 2,085,000 having been placed at the close of work on Oct. 29. Work has been begun on the concrete cut-off walls, which will extend from the east side of the upper lock into the hill on which the division office is situated, this hill forming a part of the dam. The floor in the middle lock is about 80% completed, and the construction of the wall monoliths is advancing rapidly. On Friday morning, Oct. 28, the cableways established a new hourly record, when 244 cu. yds. of concrete and 28 cu. yds. of hard rock, a total of 272 cu. yds., were placed from 8 to 9 o'clock.

On Oct. 29, in the afternoon between 1 and 2 o'clock, tower No. 4 of the lock cableways placed 98 cu. yds. of concrete, 48 cu. yds. on cable A and 50 on cable B.

The records at the locks on the Pacific side are as follows:

The estimate of the amount of concrete to be laid in the locks at Pedro Miguel and Miraflores during October was 82,500 cu. yds. At the close of work on Oct. 30, all but 2,954 cu. yds. of this amount had been placed. On Monday, Oct. 31, 3,537 cu. yds. were laid in two locks, bringing the combined total up to 83,083 cu. yds. and exceeding the estimate by 583 cu. yds. Both plants were operated on the last two Sundays of the month. On Sunday, Oct. 23, the two mixers in No. 1 berm crane at Pedro Miguel were operated for a total of 6¼ mixer hours, and at Miraflores, two ½-cu. yd. mixers were operated for a total of 14 mixer hours. On Sunday, Oct. 30, the construction and auxiliary plants at both locks were operated on full time.

The concrete work in the Pedro Miguel Locks is a little over 44% completed, 369,285 cu. yds. out of a total of 837,400 having been laid at the close of work on Oct. 29. The quantity placed in both the Pedro Miguel and Miraflores Locks during October—83,083 cu. yds.—exceeds the previous best monthly record, that of Sept., 1910, by about 14,000 cu. yds.

On Friday, Oct. 28, No. 6, one of the new ½-cu. yd. mixers in service at Miraflores locks broke. It is believed, all local records of output for a mixer of this size in one day, by producing 190 cu. yds. in 7½ hours actual working time, an average of one batch of concrete every 2½ mins. The same mixer nearly duplicated the performance on Sunday, Oct. 30, when it turned out 186 cu. yds.

The Decision in the Long-Delayed Peoria Electrolysis Suit.

At various times we have noted in Engineering News the progress of the actions brought by the Peoria Water Works Co. against the Central Ry. Co. of Peoria, Ill., to restrain the railway company from so operating its electric railway system that destruction of the water mains and service pipes of the water company was possible. (See Eng. News, March 22, 1894; July 19, 1900; Jan. 24, 1901; Aug. 19, 1909.) We briefly noted the reported opinion of Judge A. L. Sanborne in our issue of Oct. 20. The text of the decision is now available and portions are given below.

The taking of evidence for the injunction suit was begun in 1898 before Special Master F. L. Wean, who was appointed by Judge P. S. Grosscup. The first report of the Master was delivered May 30, 1901, and arguments were heard on the defendant's objections to the Master's report in June, 1902. On account of the difficulty of the case and the importance of the interests involved, there was considerable delay and the case was transferred by Judge Grosscup to Judge Sanborne in the Circuit Court for the Northern District of Illinois, Eastern Division. A rereference to the same Master was made. Evidence on the rehearing was taken in March, April and June, 1908, and the Master's second report was published on June 1, 1909. The major part of this report was reprinted in Engineering News Aug. 19, 1909, p. 186. It only confirmed the former findings and the contentions of the water company in general were upheld.

The Master found that a difference in potential of a fraction of a volt might cause electrolysis and that the ultimate destruction of the pipes of the water company by currents escaping from the railway system was a question only of time and pressure. (Conclusion XIV. of the first report.) It was held that the evidence disclosed no known method by which the water company could protect its system of pipes from the railway currents. (XV. in the first report.) Moreover, it was held that no complete remedy for the injury to these water pipes was possible except the entire removal of current from the water mains, and that to this end the return circuit of the electric railway, or in other words the track, could not be grounded or in contact with the earth. It was reported that the way was open for the street-railway company to keep its currents off the water mains by use of a double overhead trolley, the only question being held to be that of expense. (XVI., XVII. and XX. in the first report.)

The Master reported that failure to prevent electrolysis would result in taking property for public purposes without due process of law, and that the water company was entitled to relief in the form of (1) an injunction to prevent further injury, and (2) damages or injuries already done so far as ascertainable.

Judge Sanborne has not wholly sustained the report of the Master in the case, either in the merits of the case or in matters of law, as the following extracts from the decision will show. This decision was given Sept. 30, 1910, and filed Oct. 5. A decree for injunction has not issued in accordance with the findings of the court as given below, as opportunity will be given to argue on the decision.

COMPLAINANT'S CONTENTIONS.—Complainant's contentions are as follows: Defendant is using the water mains and service pipes as part of its negative return system, inducing electrolysis or chemical decomposition of mains and pipes. Owing to the necessarily jointed construction of the mains, being connected by lead joints forming an imperfect electrical connection between the pipes, electrolysis results by the passage of a current through the wet earth around each joint, the "anode" joint being injured. Similar damage is claimed to result at those places on the pipe where the current leaves it to pass to other underground structures, or back to the railroad track; and also upon the lead service pipes of complainant. It is further claimed that the smallest fraction of a volt difference in pressure or potential on the pipes will cause their gradual decomposition and destruction. It is alleged, and found by the master, that the ultimate destruction of complainant's system is only a question of time and pressure, under present conditions; that complainant can do nothing to lessen the injury, while it is feasible for defendant, by putting in an insulated metallic circuit by means of the double trolley or otherwise, to entirely prevent the escape of current from its circuit.

DEFENDANT'S CLAIMS.—By the ordinances recited in the master's report it is required to operate the plant by the single overhead trolley system, and it cannot therefore be required by the court to install another system. As found by the master, defendant has done everything possible for the safe return of current, in the present state of the art, so long as the single trolley is used. Defendant's acts are claimed to be authorized by legislative authority, and even though incidental injury be done to the water system it is *damnum absque injuria* ["damage without injury"; as in the case of an accident for which no one is to blame—Ed.]; nor is the evidence it is argued, or master's report, sufficient to justify an injunction against operation without an insulated circuit. It is further insisted, even if serious injury is being done to the water pipes, that the remedy suggested calls for the exercise of the police power for protection of the public safety, to be applied only by the legislature or city council, and not by the court. In other words, the court can exercise only judicial, not legislative functions. Generally it is contended that the running of street railroads by electricity is practically in its infancy. New discoveries are being constantly made. Injury by electrolysis is not clearly understood, nor rationally capable of explanation, in the present state of scientific knowledge. Experts are changing their views in respect to the alleged danger of injury. The attitude of municipal authorities has been one of waiting and experiment. Some 1,600 single-trolley systems exist in the United States, and only one or two double-trolley systems. The injury in Peoria is not one general to the whole piping system, but is localized to the region near the power station; and the damage is growing continuously less and less by better methods of negative return all over the country, and particularly in Peoria. There is no great or irreparable injury, it is said, sufficient to justify the restraining of the public service of carrying passengers in defendant's cars, except on condition of installing the double trolley, or other insulated system. Further, the installation of the double trolley is unreasonably expensive, and its use is dangerous, nor will it entirely prevent the escape of electric current into the ground, and upon the water pipes, so as to cause injury.

DECISION OF THE COURT.—At the outset it may be said that the court has no power to prescribe by injunction the use of any particular system of circuit or negative return. It is doubtful, indeed, whether the judicial power would extend to the making of a decree restraining the defendant from continuing to serve the public unless it shall cease injuring complainant's water system. The utmost possible relief is to restrain defendant from continuing the injury, assuming for the present that sufficient damage is shown, and punishing it and its officers for contempt in case of disobedience, leaving the means of curing the injury entirely to its discretion. In case of such a result, a decree might be rendered in contempt proceedings brought in this suit on the equitable side, awarding compensation for such injury as might be shown, with incidental punishment. Or a proceeding for a criminal contempt might be brought, in case of deliberate disobedience, in which a fine or imprisonment might be imposed. (Bessette v. Conkey Co., 194 U. S. 324, 24 Sup. Ct. 665, 48 L. Ed. 997.)

That no specific system can be imposed by the court is settled by federal decisions, passing on the essential distinctions between legislative and judicial power. "A court of chancery is not, any more than is a court of law, clothed with legislative power. It may enforce, in its own appropriate way, the specific performance of an existing legal obligation arising out of contract, law or usage, but it cannot create the obligation." (Atchison, T. & S. F. R. Co. v. Denver & N. O. R. Co., 110 U. S. 682, 4 Sup. Ct. 192, 28 L. Ed. 297, cited in W. U. Tel. Co. v. Myatt, 98 Fed. 335, 343.) "In this way, it seems to us, the court has made an arrangement for the business intercourse of these companies (express and railway), such as, in its opinion, they ought to have made for themselves. The regulation of matters of this kind is legislative in its character, not judicial." (Express Cases, 117 U. S. 1, 6 Sup. Ct. 628, 29 L. Ed. 791.) "A judicial inquiry investigates, declares and enforces liabilities as they stand on present or past facts, and under laws supposed already to exist. That is its purpose and end. Legislation on the other hand looks to the future, and changes existing conditions by making a new rule to be applied thereafter to all or some part of those subject to its power. The establishment of a rate is the making of a rule for the future, and therefore is an act legislative, not judicial in kind." (Justice Holmes, in Prentis v. Atlantic Coast Line, 211 U. S. 211, 226, 29 Sup. Ct. 68, 53 L. Ed.) The reasonableness or propriety of the means to be adopted by electric railroads to prevent or lessen injury to gas pipes, water pipes, etc., is essentially an administrative inquiry, legislative in its nature when considered and administered by the legislature, city council or public service commission, administrative when considered and applied by the corporation itself. (Spring Valley W. Co. v. San Francisco, 165 Fed. 667, 678. And in Dayton City R. Co., 12 Ohio Dec. 258, affirmed on appeal, 16 Ohio Circ. Dec. 736, the same rule was substantially applied. Cleveland T. & T. Co. v. United Elec. R. Co., 42 F. 273, seems opposed to this view of the law.)

The whole duty of defendant is to make the damage as little as possible by using the best means reasonably within its power; the selection of such means to be left to its discretion, and at its peril of failure to exercise such discretion in a fair, bona fide way.

The master reported that the injury is continuous, permanent and constantly increasing, by reason of increased traffic, extension of the railway line, and the running of heavier cars, including interurban cars, and that the ultimate destruction of the water pipes is inevitable. That a difference of potential of the fraction of a volt may cause electrolysis. That there is no complete remedy except the entire removal of electric current from the water mains, and no method except an insulated circuit will prevent the escape of a portion of the current into the ground and water pipes. Exceptions to these conclusions have been filed, and are now presented for approval or modification.

Damage to the water pipes by electrolysis in Peoria is inferred by the witnesses from the conditions found to exist on examination of the pipe, and is described in the testimony. . . . It is indeed stated by some of the expert witnesses that wherever the current leaves a pipe electrolysis occurs, stripping off small particles of the pipe metal, and gradually destroying it, in direct proportion to the amperage, or volume of current flowing on the pipe. But under all the testimony and from common observation, it is clear that the mere passage of electricity from one substance to another is not electrolysis, the metals being conductors, without decomposition, and is not necessarily attended with injury at the point of escape. Mr. Waterman, an experienced electrical and railway engineer testified that the water around a pipe will carry electricity either conductively, without damage or decomposition, or electrolytically, with injury to the pipe and decomposition of the solution. Also that there may be electrolysis of the solution without injury to the pipe. Prof. D. C. Jackson, who has made a thorough study of the practical side of electrolysis to water mains for many years, and is a most accomplished electrical engineer, says that if the anode is crude copper, containing also iron and silver, only the copper may be carried to the cathode, while the iron and silver may go to the bottom of the tank. This illustrates the position sustained by the evidence as a whole, that electrolysis is a question of surrounding conditions, and that current leaving a pipe may, or may not, be attended with injury to the pipe. Prof. Jackson's experiments tend to show that cast iron and lead plates embedded in moist earth will suffer electrolysis when a current is applied. But he did not cover the plates with silica, asphalt or other insulator, nor does he state current volume or voltage. He did not make any test with pieces of pipe covered with iron rust, which is an insulating protector.

It is inferable from the evidence as a whole that wet earth, surrounding a water pipe, may, by containing some solution not described, possibly iron, iron rust, common salt, sulphate of zinc, nitrode of soda or carbonate of lime, become an electrolyte, decomposable by having an electric current pass through it; and also, under some conditions not described, and apparently unknown, particles of the iron pipe, or anode, may be stripped off and pass into the electrolyte solution, or possibly be carried over to some unknown cathode, as in the process of silver plating. Analysis of samples of soil taken from two places above a water main showed from 2½ to 3½% of iron, and ½ to 1% of soluble salts, composed of sodium chloride, potassium nitrate, lime and a small amount of sulphates.

The testimony shows that one ampere constantly leaving a pipe for 18 hours a day under electrolytic conditions will take away 15 lbs. of iron per annum. Yet in 8½ years not a single break in a water main occurred, although the rails were at that time very poorly bonded. Prof. Jackson during this period found a volume of 75 amperes on some of the water mains.

Injury to the ends of water pipes, near the joint, may also result from the current flowing from one pipe to another. The pieces of pipe are 12 ft. long, and are covered with a non-conducting coating. It is not convenient to so join the pipe sections as to obtain a complete metallic contact between them. . . . As a result there is a break in the conductivity of the pipe every 12 ft. However, the joint resistance is very much less than the soil resistance around the main, as well as of the water in it, pure water being nearly a non-conductor, although absolutely pure water has probably never been produced. It follows, therefore, that the current will take the path of least resistance through the joints, rather than the path of much higher resistance around them unless an electrolyte is found near the joint, or in the water in the pipes, of such a character as to divert the current from its natural path. When this shunting will occur,

how often, no one knows. Many of the witnesses say that the joint resistance becomes so great that the current will shunt around the joint through the outside earth, or the water in the pipe, and that when it leaves the pipe it causes injury. It appears that most of the joints must make a high resistance. If the current were shunted around these joints, and invariably resulted in injury to the pipe, it would not take long to destroy the whole water system. In many years there was not a single break in a water main from electrolysis. During the same period only 88 out of 5,000 service pipes were destroyed by it. Out of 9,000 service pipes there were 12 breaks in 1903, eight in 1906, five in 1907, and two in the first four months of 1908. During the same four months there were two joint leaks, four in 1907, 12 in 1906, seven in 1905, nine in 1904 and 14 in 1903. As a result of three tests at different places, of a large number of pipes, made in 1903, 1904 and 1906, the percentage of pipe damage in 1903 was found to be 20, 15 in 1904 and ten in 1906. The same tests showed the average current on the water pipes in 1903 3½ amps., four in 1904 and six in 1906; and a test in 1908 showed an average of 24. These tests were by no means universal of the system and should not be given any undue weight. But they tend to show a progressively lessening average damage. In particular places, especially near the power station, steadily increasing damage by electrolysis appears, but on the average the evidence shows it is lessening. One reason for improvement is better bonding of rails and more attention to negative return feeders. Another seems to be that as electrolysis proceeds, and the pipes become rusted, the oxide formed increases the electrical resistance of the pipe coating, and thus prevents further electrolysis except under unusual conditions. It seems also, that the decomposition of the water in the electrolyte sets up a great resistance to further electrolysis, and tends to stop it. The proof as a whole conclusively shows that no dependence whatever is to be placed upon the numerous general statements of the expert witnesses to the effect that whenever current leaves a pipe injury occurs. With an increasing current there is found diminishing damage. These experts have entirely failed to harmonize the undisputed facts shown by actual inspection of pipes and actual tests of current flow with their theories of decomposition of metallic substances in the earth, by electrolysis, attended by decomposition of the pipes themselves.

Especially unsatisfactory is the theory of complainant's witnesses adopted by the master, that the smallest amount of current may cause injury; that "A difference in potential of a fraction of a volt may cause electrolysis." As a laboratory theory this sometimes is true, and sometimes not, but as applied to a general system of water pipes it is utterly untrustworthy. This inference is made by some of the witnesses because a small pressure is sometimes found on a pipe showing small damage, made at some other time, and by some other pressure, both absolutely unknown. Defendant's experts generally agree that a small amount of current is not injurious. Complainant's witnesses are convinced to the contrary, and the master has followed them; but the finding is quite unsatisfactory, and so inconsistent with the nature of electrolytic action, and with the facts clearly established by undisputed evidence as to actual damage, that it cannot be sustained. It is also inconsistent with the theory of increased resistance due to water decomposition in electrolysis.

Lead service pipes have also to some extent been injured by electrolysis, especially near the power station. Altogether there are about 9,000 of them. During the 19 years from 1890 to 1909 there have been 217 breaks in service pipes attributed to electrolysis, and many more from other causes. From electrolysis there were 12 breaks of service pipes in 1905, eight in 1906, five in 1907 and two in the first five months of 1908. These service pipes are many of them under the street-railroad tracks, and the theory of damage is that when the iron pipes are positive to the rails the current flows from the mains through the lead pipes, and then through some electrolyte in the earth to the rails, decomposing the service pipe as it goes. This injury, like that to the mains, is shown to be lessening, and the percentage of damage is not enough to show danger of the ultimate destruction of these lead pipes, even of those in the region of the power station where almost all the breaks have occurred. Repairs to service pipes are paid for by the water consumer. It may be that the use of galvanized iron service pipes instead of lead, near the power station, might be an improvement, but this will be left to the judgment of complainant.

Complainant's water-works system is being damaged by electrolysis caused by electricity generated by defendant, but not so seriously as reported by the master. This injury should be stopped. Complainant cannot, in the present state of development, find any reasonably practical way to cure it. Both parties insist that the injury is curable, but they differ as to means. The subject has been most seriously studied by many engineers, and there is a difference of opinion among them whether anything short of a metallic circuit will be a complete remedy. Many other plans have been tried. The effort has been to so perfect the rail return as to prevent escape of current into the earth. No claim is made that this can be fully done, but some eleven witnesses testified on the second reference that the rails can be so bonded and cross bonded as to practically stop electrolysis of the water pipes, with the assistance of other means of negative return. Nearly as many other witnesses are of opinion that no such thing is possible, and the master agrees with them, and has recommended the compulsory installation of a metallic, non-rail return circuit.

Four plans of improving the rail return are explained by defendant's witnesses, which they think practically efficient. They have been used more or less since 1890. All of them contemplate the use of the brazed rail bond, of which the defendant had installed about six miles at the time the testimony was closed on the second reference. This bond consists of a number of leaves of thin copper folded back and forth on themselves, with a piece of brass wound around the end, and applied to the side of the ball of the rail near the end. The rail is first ground with an emery wheel to make it clean and bright. Then the end of the bond is clamped between a carbon plug and the rail, and subjected to a current of 2,000 amps. passed through bond and joint until the brass melts and flows upon the clean rail surface, thus making a perfect and permanent electrical contact. Each bond is equivalent in conductivity to three feet of rail, that is one-fourth as great a conductivity as that of a continuous rail, and each has a greater conductivity than the trolley wire.

The first plan consists in the use of some efficient form of rail return, as the brazed bond, welded joint, etc., with cross wires between rails and assisting the return by feeder wires from rail to negative side of dynamo, at regular distances from the power-house. This is the system now in use in Peoria.

The second plan is called the quadrilateral or constant-potential system, and is simply a modification of the first, with additional bonding at crossings and switches. This system is recommended for Peoria by defendant's witnesses, with a possible addition. It was called quadrilateral because of its supposed application to the case of a railway surrounding the center of a city, and forming a four-sided network of rails, requiring a four-sided system of negative return copper wires from the track, and bringing them together to the negative side of the dynamo. The purpose is to reduce to a constant potential all the negative feeder points, and by expanding the feeders in the shape of a fan, to equalize the pressure all over the rail system, thus preventing as much as possible the escape of current from the rails, and its return to the power-house. The system was installed in Richmond, Virginia, and is claimed to have reduced the amperage on the water pipes from a varying current of considerable size to a maximum of less than one ampere. It is also being put in at Toronto. The underlying idea is that the tendency to leakage of current from the rails varies as the square of the distance between feeders, so that the putting in of an additional feeder divides the distance by two and the leakage by four. In Richmond, four copper wires, ¾-in. in diameter, were attached at one end to the negative bus bar at the station and at the other each to an extended network of smaller wires attached to the rails. Each system of wires extended in a different direction.

The third plan is called the drainage system, often used to protect the sheathes of telephone cables. In this the rails and pipes are regarded as a parallel conductor system of return feeders, pipes and rails being connected by copper wire. This can only be put in when the owners of both systems are working in harmony. It is in use in Rochester, New York, where it is claimed to have avoided trouble from complaint of electrolysis. The testimony as to its efficiency is conflicting.

The last plan is not fully described in the proofs. By this it is sought to constantly keep the whole piping system negative to the rails, so that no current can flow from pipe to rail. This may be done by copper wire, or by a "negative booster" an additional dynamo so connected with the pipes as to produce upon them a lower potential than upon the rails.

The quadrilateral or constant-potential system is recommended for Peoria by defendant's witnesses, and one also suggests a limited use of the drainage system in addition to the other, but thinks it would not be necessary for the protection of the pipes.

Defendant's expert witnesses agree in testifying that no system will prevent all leakage of current, but think that the quadrilateral plan will be a substantial success. Complainant's witnesses believe it to be necessary to keep all the current from the rails by the double trolley or other insulated system, and that if any current whatever gets upon the pipes they will be destroyed. This conclusion is not established by the evidence. The fourteenth, sixteenth, seventeenth and paragraphs five and six of the twentieth findings of the master on the first reference [see note above—Ed.] are not sustained by the proofs. The findings on the second reference need modification according to this opinion.

Defendant should be enjoined from continuing the injury to the complainant's water mains and service pipes, and should be given a reasonable time to take such measures, or put in such improvements to its negative return, as will substantially prevent injury. This should be upon condition that complainant cooperate with defendant so far as reasonable and proper, in aiding it to prevent or lessen the escape of current from its rails, or in preventing the escape of current from the water pipes in such manner as to cause injury thereto. The matter of the terms of the decree in these respects, as well as the modification of the findings, will be further considered on application for decree.

As to costs I am inclined to think that neither party should have costs as against the other, and that clerk's, marshal's and master's fees should be equally divided between the parties. Fees and expenses of witnesses, experts and engineers, and for examinations and tests, should be borne by the party calling the witness or requesting the services.

First Annual Meeting of the American Association for Study and Prevention of Infant Mortality.

By C.-E. A. WINSLOW.*

Almost all health problems have a dual aspect, medical on the side of the individual, engineering on the side of the environment. Medical interests tend to predominate in regard to the prevention of infant mortality, more perhaps than in any other branch of public health work. Yet even this subject brings in its own engineering problems as was evident at the first regular meeting of this association, organized at New Haven a year ago. Furthermore, the fact that 13% of the babies born in all the civilized countries of the world die in the first year, from diseases at least half of which are preventable, makes this a problem of pressing social importance to every profession and to every class.

The first annual meeting of the Association was held in Baltimore, Md., from Nov. 9 to 11, 1910. After a general meeting at which the speakers were the French Ambassador, Prof. Irving Fisher, Dr. Abraham Jacobi and Dr. W. H. Welch, the Association was resolved into four sections. In the first session on Philanthropic Prevention (Dr. Hastings H. Hart of the Russell Sage Foundation, chairman), it was emphasized that housing conditions in insanitary tenements form one of the contributory causes of high infant mortality and that the problem of poverty underlies all its most serious aspects. Education, however, can forestall many of the evils which naturally follow in the train of poverty and most encouraging results were reported by the New York Milk Committee and other similar bodies from organized movements for teaching mothers how to care properly for their offspring.

In the session on Municipal, State and Federal Prevention (Dr. William H. Welch, chairman), the paper of most general interest was a strong presentation of the need for better birth statistics by Dr. Cressy L. Wilbur, of the Census Bureau. The registration area for deaths now includes 55% of the population of the United States, but not a single state or city has really adequate birth records. According to Dr. Wilbur, registration of these fundamental facts in vital statistics is worse in Baltimore, Chicago and New Orleans than in any other civilized cities in the world. Dr. J. S. Neff, of the Board of Health of Philadelphia, described before this section the excellent results attained by the Division of Child Hygiene through its organization of home instruction by nurses and physicians.

Papers read before the section on Medical Prevention (Dr. L. Emmett Holt, of New York, chairman), were generally technical in nature but an exposition by Dr. I. S. Wile of the shortcomings of the instruction now given in medical schools in regard to the care and feeding of children aroused considerable interest. The possibilities of medical training along all the various lines of preventive medicine have not yet begun to be realized.

The fourth and last session on Educational Prevention (Dr. Helen C. Putnam, chairman) was devoted to a study of the machinery at work in Normal schools and colleges for fitting teach-

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ers to do their fundamental part in the great educational work which underlies all the campaign for public health. Stimulating and impressive reports were made from Cornell and Wisconsin, and from Normal schools in Pennsylvania and Michigan, of broad and well-planned courses in biology, sex hygiene, home-making and school sanitation; the latter at Cornell involving the use of instruments of precision for chemical and physical examination of the air. This, with the philanthropic activities reported at the first session, furnished the most hopeful and important features of the meeting.

An extensive exhibit was prepared for the meeting under the general supervision of Dr. Marshall L. Price, of the Maryland State Board of Health, to illustrate the principal causes of excessive infant mortality and practical means for their control.

The Life of an Automatic Sprinkler.*

By C. R. ALLING.†

The life of an automatic sprinkler is not indefinite under any conditions, and under certain conditions it may be comparatively short. The sprinkler fire record would be even more favorable than at present were this more generally known and proper precautions taken to protect sprinklers from influences detrimental to their operation. The automatic sprinkler is generally recognized as the most effectual fire extinguisher agent yet developed, and considering all that it has to contend with in the way of faults in design, errors in construction, mistakes in installation and mistreatment in service, it is surprising that its general showing is so favorable. It is surely deserving of better supervision, care and maintenance.

Up to the present time no sprinkler has been designed which will prove entirely reliable when exposed to very severe loading or corrosive conditions for long periods of time. The life of some types of sprinklers is longer than others, due to their more perfect design or excellence in manufacture, thus increasing their ability to better withstand these influences. Also, the life of some types of sprinklers will be longer where there are no corrosive atmospheric conditions than other types for the same reasons. Thus it will be seen that the life of a sprinkler depends on the excellence of its design and construction, as well as upon the influence of surrounding conditions.

Some types of sprinklers were, in the early days of manufacture, made of cast iron. These were unduly susceptible to influences of corrosion, and experience soon taught the pioneers of this industry that most all parts of a device of this character should be made of metals which would be least subject to deterioration and, therefore, for the last 25 years, practically every manufacturer has employed brass, bronze, or some similar alloy, which will be the least affected by conditions to which an automatic sprinkler is normally subjected. At the present time there is probably not a sprinkler in service in which the more essential parts are made of any material other than bronze or some other copper-tin alloy.

Tests conducted at the Laboratories upon old sprinklers taken from the field, and having been in service for varying lengths of time, show that the greatest and the most common causes of failure are corrosion and loading. Corrosion usually acts upon the solder, changing the chemical composition upon the surface and forming a crust. Continued exposure will sometimes entirely disintegrate the solder and weaken the members. This is especially so in the early types of sprinklers.

A large number of sprinklers have been tested at the Laboratories from equipments where the corrosive conditions are fairly severe, such as paper mills, stables, fertilizer plants, tanneries, dye houses, sulphite mills, aniline works, soap factories, etc. These tests indicate that no sprinkler will remain in good condition indefinitely, and that the only way in which it can be determined whether the heads are in a reliable and operative condition is to test representative samples under conditions that may be met with at time of fire. It has been found in a number of instances that although the sprinklers appeared to be in fairly good condition before the test, they were absolutely inoperative, while in other cases the corrosion appeared to be sufficient to render the heads inoperative, but upon test they were found to be reliable.

Various attempts have been made by the sprinkler manufacturers to protect heads which were to be installed in locations unusually subject to corrosive influence, but none of these have been entirely successful. One method consisted in covering the entire sprinkler above the wrench head with a glass cap, the idea being that the heat from a fire would either be sufficient to crack the glass or else the heat would be transmitted through the glass to the soldered joint so that when the releasing device operated the water pressure would be sufficient to blow off the cap. The principal objection to this was that the sensitiveness of the sprinkler was materially decreased.

Another method which is probably more successful consists of coating all parts of the sprinkler with mineral wax compositions having melting points below that of the ordinary degree solder, so that in case of fire the composition will melt and leave the parts free from corrosion before the heat becomes sufficient to fuse the solder. This method of protecting the sprinklers has generally given satisfactory results for a limited time, the principal defect being that under severe conditions the coating dries out or becomes cracked by expansion and contraction, thus allowing the corrosion to work in and attack the metal parts. No successful method of protecting high degree sprinklers has yet been devised.

Sprinklers located in plants where they are subject to loading will become inoperative in a comparatively short time, the clogging effect of the loading being often just as effective in rendering the sprinkler inoperative as severe corrosive influences. This is evidenced by tests of sprinklers taken from various mills where they were subjected to loading from paper pulp, sawdust, drying oils, lint, caked dust from grinding processes, etc., etc. The character of the loading is somewhat different in almost all cases, varying from a thin hard crust to a thick, heavy, fibrous coating. All of these loadings tend to accomplish the same result; i. e., to clog the parts so that the releasing device cannot operate freely, if at all.

The life of an automatic sprinkler depends primarily upon its design, accuracy in workmanship, and ability to retain sufficient motive power, independent of water pressures, to overcome all reasonable obstruction to its free operation for extended periods. Tests made at the Laboratories upon old sprinklers indicate that inaccuracy in the machined surfaces and bearings are largely responsible for the slow actions of the releasing device, resulting in partial opening of the link, and in some cases the resealing of the solder by the water. This is caused by a slight set between the parts, and consequent loss of the motive power necessary for the proper operation of the parts. The more modern sprinklers contain features which increase the chances of the releasing device operating favorably, or aid in its continuous movement.

From the foregoing it would appear that property owners, as a rule, need to be brought to a realization of the fact that the life of an automatic sprinkler is not indefinite. The need for replacing old, obsolete and injured heads should be constantly borne in mind. The exercise of care and intelligence in making such replacements is, of course, essential. Automatic sprinklers are, sometimes found in service which will manifestly fail under ordinary fire conditions, but in the majority of cases, the demarkation between reliability and unreliability in the device cannot be accurately made except by Laboratory tests conducted by men trained in the business.

*Condensed from an article in the "Quarterly of the National Fire Protection Association" for October, 1910.
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Steel Cars for the Chicago Freight Tunnels.

The Illinois Tunnel Co., of Chicago, operates a system of about 50 miles of narrow gage underground railway, handling freight between stores, warehouses and railway stations, and also delivering coal to and removing ashes from office and mercantile buildings, etc. The tunnels, which have been described in our columns, are 7 × 9 ft. in section, and are at a depth of about 40 ft. below the street level. The tracks are of 24 ins. gage, and the lines are operated by electric locomotives.

All the cars are of steel construction, and the accompanying cut represents one of the latest cars for general freight service. It is 12 ft. 3⅞ ins. long and 3 ft. 9½ ins. wide over all, with a total height of 5 ft. 1 5-16 ins. above the rails. The sills are Z-bars, and the stakes are of steel pipe, fitted into pockets riveted to the sills. The sides and ends can be removed (the steel plates being riveted to the stakes), so that the car is adaptable for large or small packages and for various kinds of freight. The equipment includes automatic couplers and spring draft-gear.

STEEL CAR FOR THE UNDERGROUND FREIGHT RAILWAY SYSTEM OF THE ILLINOIS TUNNEL CO., CHICAGO (24 INS. GAGE).

No brakes are fitted; the train being controlled by the engine brakes. The trucks have cast-steel side frames and bolsters. They have 24-in. wheels and a wheelbase of 27 ins., and are spaced 6 ft. 3 ins. between centers. The carrying capacity is 15,000 lbs., and the weight of the car is 3,610 lbs.

The Kilbourne & Jacobs Mfg. Co., of Columbus, O., has built 500 of these cars, and we are indebted to that company for photograph and other information.

Notes from Engineering Schools

PURDUE UNIVERSITY.—On Nov. 1 the two new connected buildings of the Department of Practical Mechanics were dedicated. One building is one story in height with monitor roofs, and has a U-shaped plan showing some 43,000 sq. ft. of floor area. Here are the machine, forge and wood shops, the foundry and a museum. In front of this is a three-story structure having a large lecture room seating 300 students, two class rooms, drawing rooms and offices. In the shops 350 students can be accommodated at once. In the drawing rooms is room for 400 men.

The aim of this department is to teach manufacturing in a broad way rather than to give the students a mere manual training. The machines, tools, benches, lockers and all such equipment is modern, and many features of arrangement are claimed to be unique. Shop lectures are given on different features of shop organization and arrangement. No attempt is made to produce machinery on a large scale, yet some 25 small lathes are manufactured each year. This enables the introduction of some regular manufacturing practices and increases interest in the work.

A TRACKLESS TROLLEY line has lately been installed near Los Angeles, Cal., for transferring passengers from a suburban line to a real-estate development a mile and a half away. The grade of the road for the line ranges from 5 to 12%, with a predominance of curves over tangents. Two old gasoline omnibuses were reconstructed and fitted with two 15-HP., 500-volt electric motors, each motor driving one rear wheel by chain. An ordinary series-parallel controller was mounted on the dashboard to the left of the steering wheel. Two trolley poles were mounted forward on the roof, spaced 48 ins. apart, transversely. The poles were of wood, 15 ft. long, carrying a swivel collector at the end, and themselves pivoted at their roof pedestal. These trolleys were designed to allow a total travel of 11 ft. on each side of the center of the roadway. The overhead wires, two in number of course, are of grooved copper, suspended from pipe arm brackets on convenient telephone poles. A running speed of 10 miles an hour is maintained, although a speed of 25 miles per hour is claimed possible on tangents. The system is owned by the Laurel Canyon Utilities Co., of Los Angeles. The line and apparatus were designed by Mr. R. W. Shoemaker, of Los Angeles.

An Endorsement of the Panama Canal Work by a Party of Engineers.

A remarkable testimonial to the engineering personnel of the Isthmian Canal Commission and an unqualified endorsement of the present plans for the construction of the Panama Canal has been made by those members of the American Institute of Mining Engineers who returned to New York on Nov. 15 after the 25-day trip, which included a 7-day visit of inspection over the entire Isthmus. On the voyage back from Colon, a number of meetings were held aboard ship at which the work on the Canal was discussed and it was decided to voice the opinion of the party in the signed statement which we reprint below.

SS. Prinz August Wilhelm, at sea, Nov. 14, 1910.

We, the undersigned, members and guests of the American Institute of Mining Engineers, after a visit to the Isthmus of Panama, and inspection of the work of the United States Isthmian Canal Commission, and after full discussion of our individual impressions, find ourselves in unanimous agreement as to the following conclusions:

1. The present plan of the work is clearly practicable, and the best in our judgment that could be devised under the conditions imposed. It is perhaps a question whether by the choice of a higher level some of the difficulties and uncertainties of excavation in the Culebra Cut might not have been minimized; but a higher level has its disadvantages also; and no one now seriously proposes such a plan. On the other hand, we are convinced that a canal at a lower level, and especially at sea-level, is practically out of the question; that no man can estimate its cost, or even guarantee its satisfactory completion and maintenance at any cost. We are satisfied that the sea-level canal, as proposed, if actually completed, would be inferior to the present lock canal, by reason of its necessarily narrow and tortuous channel, its liability to many disturbances from which the lock canal is comparatively free, etc. The experience gained in the Culebra Cut throws additional light upon the sea-level plan, and renders that scheme less worthy of approval by engineers than it was when with less information some eminent authorities favored it. In a word, we do not think that any prudent engineer would now recommend the deepening of the Culebra Cut below the level now fixed for it.

The creation of the great Gatun lake by means of the Gatun dam seems to us to be the best possible way of dealing with the floods of the Chagres and other streams. The location of the Gatun dam, spillway and locks is singularly favorable for such constructions; and there is, in our judgment, no reason for any anxiety as to their stability.

The one serious remaining problem is presented by the nature of the ground in the Culebra Cut. There have been extensive slides on the sides of this excavation, and more of them are to be expected; but they involve nothing more than the cost and delay of removing the material which they will force into the cut. They will ultimately end, and we regard as reasonable the calculation of the engineers in charge as to the time and money which they may call for. The results of these calculations are included in the estimates of the Commission as to the cost of the Canal and the date of its completion.

2. We are unanimous in our praise of the manner in which sanitation, excavation, transportation and construction are performed with rapidity, skill and economy. A spirit of loyalty, emulation, industry and pride seems to animate employees and officers alike. This spirit, so difficult to arouse among workers in tropical climates, is due in this case to two causes: first, the inspiring example of Colonel Goethals and his associates, and secondly, the splendid work of the sanitation department under Colonel Gorgas. The cities of Panama and Colon, though politically outside of the Canal Zone, have shared in the benefits of the sanitary administration, and reflect an unwonted cleanliness, comfort and safety.

3. We acknowledge the entire freedom and fullness with which everything we desired to see was shown to us, and everything we desired to know was told us, by the officers of the Commission. There was evidently no wish to withhold or conceal anything. On the contrary, inquiry and criticism were frankly sought and heartily welcomed.

This is but a meager summary of the points on which we are agreed. The details of individual opinion will appear later in the published report of our discussions. Meanwhile, we unite in this common declaration, which covers our conclusions on all main points. We think the present plan of the Canal is good; that the work is in thoroughly capable hands; that it is progressing satisfactorily, and that it will be completed by the date set for it, Jan. 1, 1915, and probably earlier, provided Colonel Goethals and his associates receive the hearty support of the American people, and its representatives in Congress. The canal engineers are the right men in the right place. The great work in which they are engaged is not connected with partisan politics, and citizens of all parties should combine to secure its early and triumphant completion. In that consummation every American should take greater pride than in any victory of military or political conflict.

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A BUTTING COLLISION between two freight trains on the Great Northern Ry., near Chattaroy, Wash., Nov. 6, killed eight men. The wreck took place on a sharp curve.

A LARGE OIL TANK EXPLODED in the yard of the Tidewater Oil Co., at Bayonne, N. J., Nov. 9. One man was killed and two others injured. The explosion is reported to have wrecked four buildings beside the oil tank. The fire which followed is reported to have rendered about 15 other tanks unfit for further use.

A TRAIN STRUCK A STREET CAR on a grade crossing of the Michigan Central R. R., at Kalamazoo, Mich., Nov. 12. The conductor of the street car had gone on ahead and signaled his car to cross the tracks, evidently not seeing the approaching train. Six persons in the street car were killed and about 25 others injured.

A FARMER WAS ELECTROCUTED at Estudillo, Cal., according to local newspapers, on Nov. 8, when one wire of a high-tension transmission line fell on a barbed-wire fence. It is reported that the current traveled a half mile or more along the fence wire and set fire to the farmer's chicken house. When he tried to extinguish the flames he encountered the fence wire and was killed.

A COAL MINE EXPLOSION at Panama, Montgomery Co., Ill., in the Shoal Creek Coal Co.'s Mine, Nov. 11, killed five miners and injured ten others. Fifty other men were rescued from the part of the mine where the explosion occurred.

Of the men entombed in Mine No. 3 of the Victor-American Fuel Co., at Delagua, Colo., Nov. 8, 18 have been rescued alive and 70 others are known to have been killed, according to reports of Nov. 11. Many of the men rescued owe their escape to the timely arrival of the rescue car of the Colorado Fuel & Iron Co., with an equipment of oxygen helmets.

A WATER MAIN BURST at Montreal, Que., Nov. 8, on St. Antoine St. The street was flooded from Inspector St. to Victoria Square, a distance of about 120 yds., to such an extent that traffic was stopped for three hours. The main burst at about 9 p. m., and it was nearly midnight before the water had been entirely shut off. It is reported that the delay was due to the presence of gas in some of the manholes which it was necessary to enter in order to cut off the water from the damaged portion of the main. One employee of the water department was overcome by gas in one of the manholes.

A FLOOD ON THE SEINE has been steadily rising all of the past week, and the dispatches of Nov. 15 from Paris state that on that date the water had reached an elevation of about +31.0 m. on the Pont Royal, which is about 15 ft. above normal water level at that bridge. The water at latest reports was steadily rising at the rate of about 6 ins. daily. The almost unprecedented floods of last spring, reported in Engineering News, March 24, 1910, p. 327, reached a maximum height of +33.8 m. at the Pont Royal, so that the stage on Nov. 15 was only 2.7 m. (8.9 ft.) below the highest water of the past three centuries. The openings in the subways and tunnels adjacent to the river and in the sewers emptying into the river are about elev. +32.0 m., so that if the flood persists, in a few days the conditions of overflow into the city will be repeated.

A FLIGHT FROM A WAR VESSEL was made on Nov. 14 by E. B. Ely with a Curtiss biplane flyer. A starting platform had been erected on the scout cruiser "Birmingham" which was anchored about five miles off Fort Monroe. It was intended to fly from the ship to the Norfolk navy yard, but on account of fog and rain the course could not be followed, so the aviator landed at the nearest shore.

PANAMA CANAL EXCAVATION during October totaled 2,884,382 cu. yds., a daily average of 110,938 cu. yds. for the 26 working days. The amount of concrete laid during the month was 177,945 cu. yds. and 794,721 cu. yds. of fill was placed in dams. The rainfall for the month was 14.03 ins.

THE HUDSON & MANHATTAN RAILWAY SYSTEM in New York City, operating the four tunnels under the Hudson at Morton, Fulton and Cortlandt Sts., was enlarged during the past week by the inauguration of the Sixth Avenue subway extension from 23d to 33d Sts., with new stations at 28th and 33d Sts. The length of added line is one-half mile. The structure is double-track reinforced-concrete subway, with flat floor and roof and with a concrete septum between tracks.

The opening of this line creates the unique condition of four different levels of rail transportation operating simultaneously. At Sixth Ave., the Pennsylvania Cross-town Tunnels to Long Island cross west-east on the lines of 32d and 33d Sts., above them are successively the north-south Hudson & Manhattan subway, the Sixth Ave. street-car line on the surface, and the Sixth Avenue Elevated Railway on elevated structure.

The new Pennsylvania R. R. terminal station at Seventh Ave., 31st to 33d Sts., New York City, is to be opened for westward (Pennsylvania R. R.) traffic on Nov. 27, having been open for eastward (Long Island R. R.) traffic since Sept. 8, 1910.

WIRELESS COMMUNICATION is reported to have been established between Coltano, Italy, Clifden, Ireland, and Glace Bay, Nova Scotia, with the completion of the Marconi company's station at Coltano.

VITAL STATISTICS IN KENTUCKY are to be collected and recorded, after Jan. 1, under a comprehensive system modeled along the lines recommended by the U. S. Census Bureau and now in use in Ohio and a number of eastern states.

Personals.

Mr. Phillip C. Snodgrass, Construction Engineer for the Santa Gertrudis Co., Pachuca, Mex., has resigned to accept a position with the Interoceanic Ry. at Puebla.

Dr. Edgar F. Smith, Vice-Provost of the University of Pennsylvania since 1898, has been elected Provost to succeed Dr. Charles C. Harrison, whose resignation becomes effective on Dec. 31.

Mr. H. C. May, formerly Division Master Mechanic of the Louisville & Nashville R. R. at South Louisville, Ky., has been appointed Superintendent of Motive Power of the Chicago, Indianapolis & Louisville R. R. at Lafayette, Ind.

Mr. G. M. Gray, Mechanical Engineer of the Bessemer & Lake Erie R. R. at Greenville, Pa., has been made Superintendent of Motive Power, succeeding Mr. E. B. Gilbert, who has been appointed Special Agent of the Motive Power Department.

Mr. C. W. E. Clarke, Assoc. Am. Soc. M. E., Steam Engineer with the New York Central & Hudson River R. R., New York City, has resigned, to take effect Dec. 1, in order to accept a position with the Stone & Webster Engineering Corporation of Boston, Mass.

Mr. John S. Conway, Assoc. M. Am. Soc. C. E., formerly Engineer, U. S. Reclamation Service, at North Yakima, Wash., has been appointed Chief Constructing Engineer of the United States Lighthouse Service. Mr. Conway is a graduate of the University of Pennsylvania and has been with the Reclamation Service for the past five years.

Mr. Jesse Teaford, for many years a foreman in the Bridge Department of the Southern Ry., has been made Superintendent of Bridges and Buildings of the Louisville and St. Louis Divisions, succeeding Mr. J. T. Carpenter. Mr. Carpenter becomes Superintendent of Construction on the new machine shops at Princeton, Ind., for the Southern Ry.

Mr. Brent S. Drane, Assoc. M. Am. Soc. C. E., formerly Assistant Engineer on the construction of the Carlsbad, N. Mex., Project of the U. S. Reclamation Service, and for the past two years Division Engineer in the Porto Rico Irrigation Service, has opened an office at 1118 Realty Bldg., Charlotte, N. C., for the practice of general engineering.

Mr. W. F. Martin, Assoc. M. Am. Soc. C. E., formerly Assistant Engineer, U. S. Geological Survey, on leave of absence since November, 1909, as Chief Hydrographer, Territory of Hawaii, has been appointed District Engineer of the U. S. Geological Survey for the newly created district of Hawaii. This district has been established by the cooperation of the Geological Survey and the Territory of Hawaii.

Mr. C. E. Grunsky, M. Am. Soc. C. E., former City Engineer of San Francisco, Cal. (1900-1904), and more recently a member of the Isthmian Canal Commission (1904-1905), by the appointment of President Roosevelt, and the Chief Consulting Engineer of the U. S. Reclamation Service for several years, has been made President of the American Engineering Corporation, general engineers, with offices in the Mechanics Institute Building, San Francisco.

Dr. Allerton S. Cushman, Assistant Director of the Office of Public Roads, U. S. Department of Agriculture, has resigned and will establish a laboratory in Washington, D. C., for the purpose of engaging in original research. He will retain connection with the Department of Agriculture in an advisory capacity. Mr. Cushman is a Harvard graduate, class of 1896, and since 1902 has been Chemist in charge of investigations at the Office of Public Roads.

Messrs. Tuan Chin and Siu Lieouliang, two of China's delegates to the International Railway Congress of last summer, are making an inspection of the railways of this country before returning to their own country. Mr. Chin is a member of the Chinese Imperial Board of Posts and Communications and Mr. Lieouliang is Chief Engineer of the Chekiang & Kiangsu R. R. Mr. Chin is reported to have said that he considered the American railways superior to any in Europe. They left China by way of the Trans-Siberian Ry. and have visited all the industrial countries of Europe.

A new town has been established on the Government Reclamation Project at Belle Fourche, So. Dak., and has been named Newell by its citizens in honor of Mr. Frederick H. Newell, M. Am. Soc. C. E., Director of the United States Reclamation Service. The town is at present the terminus of a branch of the Chicago & Northwestern Railroad System. At the auction sale of business lots on Oct. 27, 107 lots were sold for a total of $31,915. About 80 buildings have already been erected in the town. The town site is surrounded by a large area of Government land which will soon be open to settlement under the Reclamation Act.

Obituary.

George L. Westcott, a contractor and builder of Bar Harbor, Me., died in that city on Nov. 9 from pneumonia. Mr. Westcott was formerly of Portland, Me.

Uriah Cummings, President of the Cummings Cement Co., of Akron, N. Y., died at his home in Stamford, Conn., on Nov. 11. He was born in Arkon on April 30, 1833, and had long been a prominent manufacturer of hydraulic cement.

John Watson, an iron contractor of Montreal, Que., died at the Royal Victoria Hospital of that city on Nov. 6. Mr. Watson was born in Scotland but came to Montreal early in life. He was President of the firm of John Watson & Son, architectural iron workers, and a member of the Montreal Board of Trade.

Admiral Sir H. H. Rawson, R. N., died in London, England, on Nov. 4. He was born on Nov. 5, 1843. He served in the Chinese War 1858-'61; was delegated in 1878 to report on the capabilities of defense of the Suez Canal, and was a member of International Signal Committee, 1892-'93. Admiral Rawson had seen much active service and had numerous medals and decorations for his bravery.

Henry Allen Peakes, employed for the past 16 years in the engineering department of the city of Medford, Mass., died on Nov. 5, following an operation for appendicitis. He was born in 1870 and graduated as a civil engineer from Tufts College in 1893. He soon entered the engineering department of Medford and had served continuously until his death, largely on the sewer system which was generally rearranged during the years 1894-96. He leaves a widow and four sons.

Dr. Henry Wurtz died at his home in Brooklyn, N. Y., on Nov. 8, at the age of 82 years. He was born at Easton, Pa., and was graduated from Princeton University and Massachusetts Institute of Technology. He was Chemical Examiner in the Patent Office in 1860 and Professor of Chemistry at the National Medical College at Washington, D. C. He was editor of "American Gas Light Journal" from 1871 to 1875. Dr. Wurtz was the discoverer of the minerals huntilite, animikite and wurtzilite.

Sidney W. Miller, President of the Pacific Flush Tank Co., died on Nov. 14, at his home in Chicago, Ill. He was born at Lake Forest, Ill., on Jan. 21, 1863. He graduated from Harvard University in 1885 and in 1888 went to Los Angeles, Cal., where he took up the practice of sanitary engineering. Soon afterwards he organized the Pacific Flush Tank Co. to introduce his patented siphon flush tank. He was also Assistant City Engineer of Pasadena, Cal. In 1893 he went to Chicago to exhibit his invention at the World's Columbian Exhibition, where it received the highest award in its class. He then opened an office there and made Chicago his residence. He was a member of the Illinois Society of Engineers and Surveyors.

Engineering Societies.

COMING MEETINGS.

ENGINEERING ASSOCIATION OF THE SOUTH.
Nov. 21-22. Annual meeting at Birmingham, Ala. Secy., H. H. Trabue, Carnegie Library, Nashville, Tenn.

NEW JERSEY SANITARY ASSOCIATION.
Dec. 2-3. Annual meeting at Lakewood, N. J. Secy., J. A. Exton, 75 Beech St., Arlington, N. J.

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS.
Dec. 5-6. Annual meeting at New York City. Secy., W. H. Ross, 154 Nassau St., New York City.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
Dec. 6-9. Annual meeting at New York City. Secy., C. W. Rice. 29 West 39th St., New York City.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
Dec. 7-9. Annual meeting at New York City. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

ASSOCIATION OF AMERICAN PORTLAND CEMENT MANUFACTURERS.
Dec. 12-14. Annual convention at New York City. Secy., Percy H. Wilson, Land Title Bldg., Philadelphia, Pa.

NATIONAL ASSOCIATION OF CEMENT USE[illegible]
Dec. 12-23. Annual convention at New Y[illegible] City. President, Richard L. Humphrey, Harri[illegible] Bldg., Philadelphia.

AMERICAN ASSOCIATION FOR THE ADVAN[illegible]MENT OF SCIENCE.
Dec. 27. Annual meeting at St. Paul, Min[illegible] Secy., L. O. Howard, Smithsonian Institution, W[illegible]ngton, D. C.

AMERICAN SOCIETY OF AGRICULTURAL [illegible]NGINEERS.
Dec. 27-28. Annual meeting at Lafayette, I[illegible] Secy., E. W. Hamilton, Iowa State College, Ames[illegible]wa.

CANADIAN SOCIETY OF CIVIL ENGINEERS
Jan. 2-6. Annual meeting at Winnipeg, Ma[illegible] Secy., C. H. McLeod, 413 Dorchester St., West [illegible]ntreal, Que.

INDIANA ENGINEERING SOCIETY.
Jan. 12-14. Annual meeting at Indianap[illegible], Ind. Secy., Charles Brossmann, Indianapolis, Ind.

MONTANA SOCIETY OF ENGINEERS.
Jan. 12-14. Annual meeting at Helena, Mont. Secy., Clinton H. Moore, Leyson Block, Butte, Mo[illegible]

ENGINEERS' SOCIETY OF WESTERN PE[illegible]NSYLVANIA.
Jan. 17. Annual meeting at Pittsburg, Pa. Secy., Elmer K. Hiles, 803 Fulton Bldg., Pittsburg, Pa.

AMERICAN INSTITUTE OF ARCHITECTS.
Jan. 17-19. Annual convention at San Francis[illegible], Cal. Secy., Glenn Brown, the Octagon, Washington, D. C.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
Jan. 18-19. Annual meeting at New York City. Secy., Charles Warren Hunt, 220 West 57th St., New York City.

ILLUMINATING ENGINEERING SOCIETY.
Jan. 20. Annual meeting at New York City. Secy., P. S. Millar, 29 West 39th St., New York City.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—At a meeting of the mechanical section Nov. 10 in Montreal, Mr. J. A. Shaw read a paper on "Power Plant Practice."

BROOKLYN ENGINEERS CLUB.—At the regular meeting Nov. 10, Mr. James B. Van Vleck presented a paper on "Engineering Work by the Bureau of Sewers in Brooklyn Borough."

CENTRAL RAILWAY CLUB.—At the regular meeting in Buffalo, N. Y., Nov. 11, Mr. Dexter C. Buell, of Omaha, Neb., Vice-President of the Union Pacific R. R., presented a paper on "The Educational Bureau of the Union Pacific R. R."

ENGINEERS' SOCIETY OF PENNSYLVANIA.—The regular monthly meeting was held Nov. 14 at Harrisburg, Pa. Mr. E. W. Dodge, General Manager of the Norton Co., gave an illustrated lecture on "Grinding Wheels, Grinding Machinery and Grinding."

INTERNATIONAL ASSOCIATION OF REFRIGERATION.—At the second international congress of the refrigerating industries, which was held in Vienna, Austria, Oct. 9-12, it was decided to hold the third international congress in the United States in 1913. Mr. J. F. Nickerson, 315 Dearborn St., Chicago, Ill., is Secretary of the American Association of Refrigeration, which is allied with the international association.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.—The program for the third annual meeting in New York City Dec. 7-10 has been arranged as follows:

Dec. 7. Morning session at Hotel Astor: Address of welcome by John Purroy Mitchel, President of the Board of Aldermen, New York City; transaction of business; "Report of Committee on Chemical Engineering Education," F. W. Frerichs; "Development of the Chemist as an Engineer," Dr. F. W. Atkinson, President of the Brooklyn Polytechnic Institute; "The Training for Chemical Engineers Which Meets the Requirements of Manufacturers," Prof. M. C. Whitaker, Columbia University; "The Fitzgibbons Boiler," Jerome Alexander. Evening session at Columbia University: Address of welcome by Prof. M. T. Bogert; reply by the President of the Institute; "Manufacture of Hydrated Lime," R. K. Meade; "The Evolution of Portland Cement Processes," Charles F. McKenna (address of retiring president).

Dec. 9. Morning session at Hotel Astor: "Manufacture of Lignite Briquettes," Henry S. Renaud; "Bleaching Oils With Fuller's Earth," David Wesson; "Action of Fruit Juices on Metallic Containers," Edward Gudeman; "Vacuum Distilling Apparatus," Phillip B. Sadtler. Evening session, joint meeting with the New York section of the American Chemical Society at Chemists Club, 108 West 55th St.: "The Principles of Sewage Disposal," Geo. C. Whipple; "Sewage Disposal in Europe," Rudolph Hering; "Sewage Disposal in New York and Vicinity," Geo. A. Soper; "Sanitary Conditions in Their Relation to Water Supplies in the Vicinity of New York," Nicholas S. Hill, Jr.; "The Unsolved Problems of Sewage Disposal," Chas. E. A. Winslow.

Excursions will be made on the afternoon of Dec. 7, morning and afternoon of Dec. 8, afternoon of Dec. 9 and on Dec. 10. Among the plants to be visited are the Marx & Rawolle glycerine refinery in Brooklyn, the chamber acid plant of the Standard Oil Co. at Bayonne, N. J.; garbage destruction plant of the Borough of Richmond, and the candle house and grease plant of the Pratt works of the Standard Oil Co. at Bliss[illegible]ille, Long Island. The chemistry buildings and laborato[illegible]es of the College of the City of New York and of Columbia University will also be visited.